Homeland Security

United States Coast Guard

Report of the International Ice Patrol in the North Atlantic

2005 Season
lletin No. 91
-188-60

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Season of 2005

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Forwarded herewith is Bulletin No. 91 of the International Ice Patrol (IIP), describing the Patrol's services and ice conditions during the 2005 season. With only 11 icebergs crossing 48°N, this was one of the lightest seasons on record, equaling 1924 as the sixth lightest in Ice Patrol's history. Though a light season offers substantial benefits in terms of more economical transatlantic shipping routes and overall reduction in the cost to conduct the patrol, it poses significant challenges toward maintaining Ice Patrol's readiness. Reviewing the historical variability in season severity proves that a light ice season in 2005 does not predict future light seasons. This variability coupled with the steady increase of waterborne commerce into east-coast North American ports underscores the fact that the risk of iceberg collision near the Grand Banks still exists. Thus, vigilant monitoring and rigorous training are key to ensuring Ice Patrol's readiness to facilitate the safe passage of hundreds of vessels. This Bulletin shows the hard work performed by Ice Patrol personnel and their partners to monitor iceberg danger and prepare for future severe iceberg years.

M.R. Hicks

M. R. Hicks
Commander, U. S. Coast Guard
Commander, International Ice Patrol

International Ice Patrol
2005 Annual Report

Contents

List of Abbreviations and Acronyms 2
Introduction 3
Summary of Operations 4
Iceberg Reconnaissance and Oceanographic Operations 8
Ice and Environmental Conditions 13
Monthly Sea-Ice Charts 24
Biweekly Iceberg Charts 31
Acknowledgements 42
Appendix A: Nations Currently Supporting International Ice Patrol 43
Appendix B: Reporting Sources 44
Appendix C: Implications of a Light Ice Season 46
Appendix D: APN-241 Radar-Detection Experiment 55
Ordering Past IIP Annual Reports from NTIS .... Back Cover

Cover photograph: CG1503 patrols north of St. John's, Newfoundland, on IRD 4.

Abbreviations and Acronyms

AOR	Area of Responsibility
AXBT	Air-deployed eXpendable BathyThermograph
BAPS	iceBerg Analysis and Prediction System
CAMSLANT	Communications Area Master Station atLANTic
CCG	Canadian Coast Guard
CIS	Canadian Ice Service
FLAR	Forward-Looking Airborne Radar
GMES	Global Monitoring for Environment and Security
HF	High Frequency
HMCS	Her Majesty's Canadian Ship
IIP	International Ice Patrol
INMARSAT	INternational MARitime SATellite (also Inmarsat)
IRD	Ice Reconnaissance Detachment
KN	Knot
LAKI	Limit of All Known Ice
LORAN	LOng RAnge Navigation
M	Meter
MBAR	Millibar
M/V	Motor Vessel
NAO	North Atlantic Oscillation
NIC	National Ice Center
NM	Nautical Mile
NTIS	National Technical Information Service
PAL	Provincial Aerospace Limited
RADAR	Radio Detection And Ranging (also radar)
RMS	Royal Mail Steamer
SOLAS	Safety Of Life At Sea
SLAR	Side-Looking Airborne Radar
WOCE	World Ocean Circulation Experiment

Introduction

This is the 91st annual report of the International Ice Patrol, which is under the operational control of Commander, U.S. Coast Guard Atlantic Area. The report contains information on IIP operations, environmental conditions, and iceberg conditions in the North Atlantic during 2005. Funded by 17 member nations and conducted by the U.S. Coast Guard, Ice Patrol was formed soon after the RMS *Titanic* sank on 15 April 1912. Since 1913, except for periods of the World Wars, Ice Patrol has been monitoring iceberg danger near the Grand Banks of Newfoundland and broadcasting the Limit of All Known Ice to mariners. The activities and responsibilities of IIP are delineated in U.S. Code, Title 46, Section 738, and the International Convention for the Safety of Life at Sea, 1974.

The International Ice Patrol conducted aerial reconnaissance from St. John's, Newfoundland, to search for icebergs in the southeastern, southern, and southwestern regions of the Grand Banks. However, the lighter-than-normal ice conditions detected on reconnaissance patrols never warranted issuing daily ice warnings. Instead, IIP issued an ice-chart and bulletin update each Friday from 18 February to 1 July 2005. In addition to IIP reconnaissance data, Ice Patrol received iceberg reports from other aircraft and mariners in the North Atlantic. (Ice Patrol salutes the *Mattea* for providing the most ship reports during 2005.) At the Operations Center in Groton, Connecticut, personnel analyzed iceberg and environmental data and used a computer model to predict iceberg drift and deterioration. Based on the model's prediction, IIP produced the Friday chart and text bulletin. In addition to these routine broadcasts, IIP responded to individual requests for iceberg information.

VADM Vivien S. Crea was Commander, U. S. Coast Guard Atlantic Area. CDR Michael R. Hicks was Commander, International Ice Patrol.

For more information about the International Ice Patrol, including iceberg bulletins and charts, visit our website at http://www.uscg.mil/lantarea/iip/home.html.

Summary of Operations

International Ice Patrol (IIP) actively monitors the iceberg danger to transatlantic shipping in the region bounded by 38°N, 52°N, 36°W, and 59°W (**Figure 1**). Ice Patrol formally begins ice reconnaissance and product dissemination when icebergs threaten the primary shipping lanes between Europe and North America. This threat usually begins in February and extends through July, but IIP commences operations when iceberg conditions dictate. Except during unusually heavy ice years, the Grand Banks of Newfoundland are normally free of icebergs from August to January.

The 2005 preseason Ice Reconnaissance Detachment (IRD) departed on 27 January to determine the prevailing ice conditions in the North Atlantic. This and subsequent IRDs observed significantly lighter-than-normal ice conditions, which never warranted issuing daily ice-limit bulletins. Ice Patrol did, however, issue weekly ice-chart and bulletin updates each Friday from 18 February to 1 July. The following statistics refer to the period of 18 February to 1 July.

International Ice Patrol's Operations Center in Groton, Connecticut, analyzed 804 information reports from IRDs, merchant ships, the Canadian Ice Service (CIS), the National Ice Center (NIC), Provincial Aerospace Limited (PAL), and other sources (**Figure 2**). Seventy-two of these reports contained ice information (**Figure 3**), ranging from single or multiple iceberg sightings to stationary radar targets and sea ice. From these reports, IIP merged 125 individual targets into BAPS (**Figure 4**), the drift and deterioration model that Ice Patrol and CIS operate jointly.

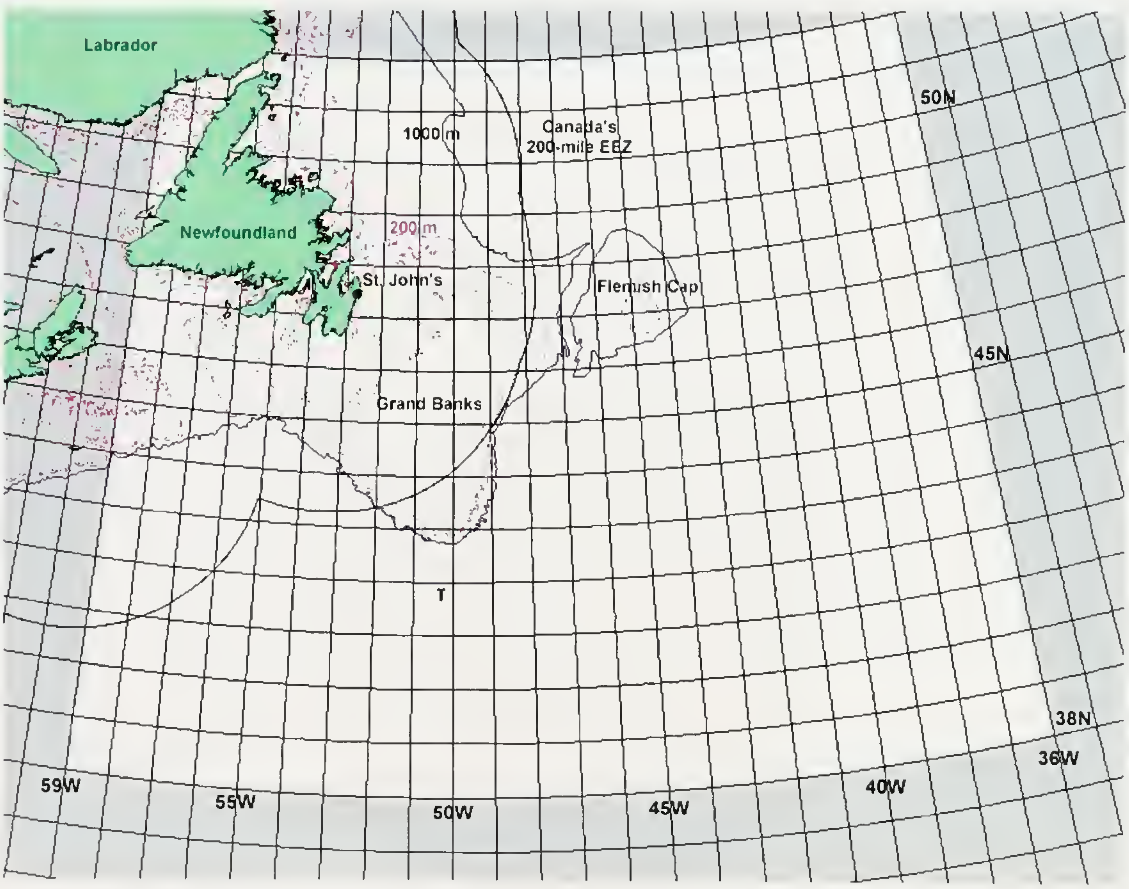


Figure 1. IIP's operating area. **T** indicates location of *Titanic*'s sinking.

Information Reports

As in previous years, IIP requested voluntary information reports from all ships transiting the Grand Banks region. Ice Patrol requested that ships report ice sightings, radar targets, weather, and sea-surface temperatures via Canadian Coast Guard Radio Station St. John's/VON, U. S. Coast Guard CAMSLANT, and—using code 42—Inmarsat-C and Inmarsat-A. Ice Patrol encouraged ships to make ice reports even if no ice was sighted because knowledge of the absence of ice is also fundamental to accurate product generation. The continued success and viability of the International Ice Patrol depends heavily upon all who contribute information reports.

Merchant shipping provided the majority of reports. In 2005, 74 ships from 25 countries provided IIP with 735 reports—92% of 804 total reports—demonstrating that the number of nations using Ice Patrol services exceeds the 17 member nations that support IIP under SOLAS. The merchant vessel *Mattea* (Canada) made the most reports to IIP in 2005, submitting a total of 92. Appendix B lists all reporting sources in 2005.

While the majority of information reports came from merchant shipping, Ice Patrol also received valuable information from many Canadian Government sources. These sources included contract reconnaissance flights by Provincial Aerospace Limited, HMCS and CCG vessels, and coastal lighthouses, all of which combined provided 39 reports, or 5% of the year's total. Finally, other sources (e.g., fishing vessels, commercial aircraft, recreation boats)—some for which the platform is unknown—provided the remaining 1% of reports. **Figure 2** provides a breakdown of the sources of all information reports received in 2005.

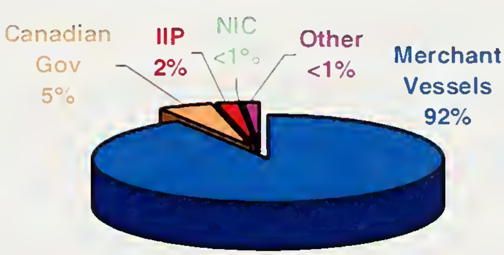


Figure 2. Reporting sources of the 804 information reports received by IIP in 2005 (Information reports include ice, sea-surface temperature, and weather.)

Ice Reports

Only 72 of the 804 reports sent to Ice Patrol contained ice information. The Canadian Government provided 53% of ice reports, Ice Patrol 24%, and the international merchant fleet 22%. The National Ice Center provided the remaining 1%. **Figure 3** displays a breakdown of ice-report sources.

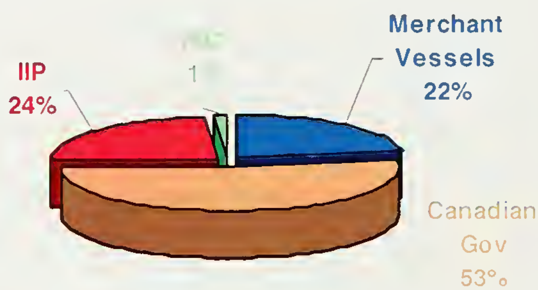


Figure 3. Reporting sources for the 72 ice reports received during 2005 (Ice reports include icebergs and stationary radar targets.)

Merged Targets

The 72 ice reports received by IIP contained 125 targets that were merged into BAPS. The merchant fleet reported 32% of merged targets, while targets transferred via BAPS made up 25%. Ice Patrol reported 22%, and the Canadian Government and NIC combined reported 21%. BAPS targets are those that were originally sighted north of Ice Patrol's AOR and entered into the CIS model, which forwarded them to IIP once they drifted south of 52°N. This BAPS configuration makes it extremely difficult to determine the original reporting source of a target transferred from the CIS model and thus explains why Figures 2 and

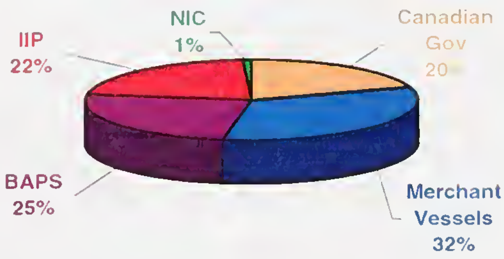


Figure 4. Reporting sources of the 125 individual targets merged into BAPS in 2005

3 do not account for targets transferred via BAPS. **Figure 4** provides a breakdown of merged-target reporting sources.

LAKI Iceberg Sightings

SOLAS mandates Ice Patrol to guard the southeastern, southern, and southwestern regions of the Grand Banks and to monitor the icebergs that set the Limit of All Known Ice (LAKI). Ice Patrol uses most of its resources to search for LAKI-setting icebergs. However, because IIP did not produce a LAKI in 2005, there were no LAKI icebergs.

Products and Broadcasts

From 18 February to 1 July, IIP issued weekly ice-chart and bulletin updates each Friday. The ice chart was broadcast at 0438Z, 1600Z, and 1810Z; the two bulletin updates were valid for 0000Z and 1200Z. Both products stated that Ice Patrol was monitoring iceberg conditions, but not issuing daily products.

Ice Patrol broadcast the weekly ice-chart and bulletin updates by the same means that daily products are broadcast. United States Coast Guard Communications Area Master Station Atlantic/NMF and Canadian Coast Guard Marine Communications and Traffic Service St. John's/VON were the primary radio stations that transmitted ice-chart updates, which were also available via plain-paper facsimile, email on demand, and the Internet. The German Federal Maritime and Hydrographic Agency stations Hamburg/DDH and Pinneberg/DDK also transmitted the ice-chart update.

Bulletin updates were delivered over the Inmarsat-C SafetyNET via the Atlantic East and West satellites. United States Coast Guard Communications Area Master Station Atlantic/NMF and Canadian Coast Guard Marine Communications and Traffic Service St. Anthony/VCM transmitted bulletin updates via radio. Finally, like ice-chart updates, bulletin updates were also available on the Internet.

Historical Perspective

Ice Patrol determines season severity based on season length (**Figure 5**)—that is, the number of days IIP produced a LAKI—and the number of icebergs south of 48°N (**Figure 6**), two measurements developed by various authors (Alfultis, 1987; Trivers, 1994; Marko, Fissel, Wadhams, Kelly, & Brown, 1994). The second measurement includes both icebergs sighted south of 48°N and those that were sighted north of 48°N but that BAPS eventually drifted south of 48°N. Of the two measurements, IIP focuses more on the number of icebergs south of 48°N because it emphasizes the degree of a season's iceberg danger to transatlantic shipping.

Only 11 icebergs drifted south of 48°N

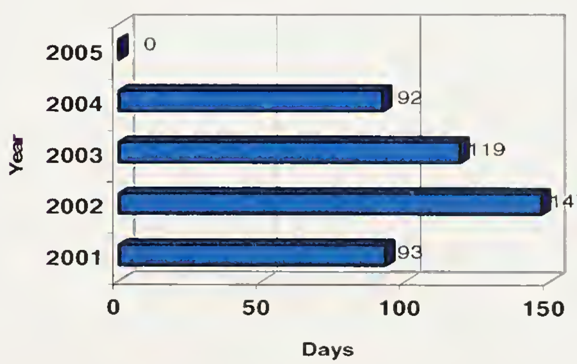


Figure 5. Number of days a LAKI was broadcast each year since 2001 (The 20-year [1986-2005] mean is 134.)

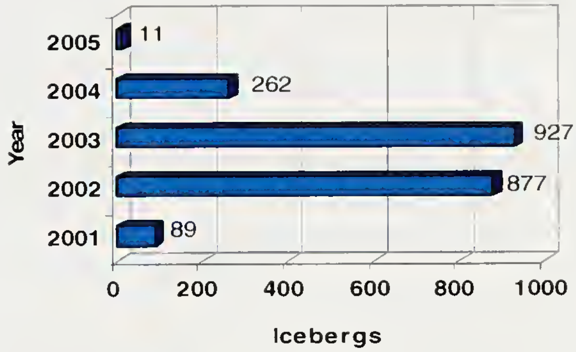


Figure 6. Number of individual icebergs (sighted and drifted) south of 48°N each year since 2001 (The 20-year [1986-2005] mean is 847.)

in 2005, and IIP never opened the season, which means that daily ice-limit products were never issued. Therefore, according to Trivers (1994)—who defined a light season as one that lasts less than 105 days and has fewer than 300 icebergs south of 48°N—2005 was an extremely light ice year.

Beginning with the 2006 ice season, IIP will align its definition of "season" with that of SOLAS, which designates the period from 15 February to 1 July as the ice season (see Appendix C for background). Consequently, season length will be a fixed period each year, and the number of days IIP establishes and broadcasts a LAKI will vary with season severity.

Canadian Support

As they do every year, the Canadian Government generously supported IIP during 2005. The Canadian Ice Service shared its valuable reconnaissance data and ice expertise with IIP. In addition, CIS provided Ice Patrol with critical support of BAPS. Finally, Provincial Aerospace Limited supplied IIP with invaluable ice data.

Customer Relations

Based on survey feedback from 2004, Ice Patrol initiated a third ice-chart broadcast time in 2005. Therefore, in addition to the 1200Z charts transmitted at 1600Z and 1810Z, IIP now broadcasts a 0000Z ice chart at 0438Z. This improvement highlights the importance of communicating with customers.

Unfortunately, however, IIP did not conduct a customer survey in 2005 because daily products were never issued. Ice Patrol will request OMB approval to conduct a survey in 2006.

References

Alfultis, M. (1987). Iceberg Populations South of 48°N Since 1900. R*eport of the International Ice Patrol in the North Atlantic*, Bulletin No. 73, 63-67.

Marko, S. R., Fissel, D. B., Wadhams, P., Kelly, P. M., & Brown, R. D. (1994). Iceberg Severity off Eastern North America: Its Relationship to Sea Ice Variability and Climate Change. *Journal of Climate*, *7*(9), 1335-1351.

Trivers, G. (1994). International Ice Patrol's Iceberg Season Severity. *Report of the International Ice Patrol in the North Atlantic*, Bulletin No. 80, 49-59.

Iceberg Reconnaissance and Oceanographic Operations

Iceberg Reconnaissance

The Ice Reconnaissance Detachment (IRD) is a sub-unit under Commander, International Ice Patrol (IIP) partnered with Coast Guard Air Station Elizabeth City, which provided the aircraft platform for reconnaissance in 2005. Ice Reconnaissance Detachments deployed to observe and report sea ice, icebergs, and oceanographic conditions on the Grand Banks of Newfoundland. Oceanographic observations were used for operational support and research purposes.

Ice Patrol's preseason IRD departed on 27 January 2005 to determine the early-season iceberg distribution. The iceberg distribution noted during the preseason and subsequent IRDs never warranted normal (once every two weeks) deployments to Newfoundland. Though IIP did not formally open the ice season—that is, issue daily ice-limit products—in 2005, IRDs deployed each month from January to July to monitor iceberg conditions on the Grand Banks. Iceberg-reconnaissance operations concluded on 28 July 2005 with the return of the postseason IRD.

Ice Reconnaissance Detachments were deployed to IIP's base of operations in St. John's, Newfoundland, for 51 days during 2005 (**Table 1**). Ice Patrol flew 31 sorties, 14 of which were transit flights to and from St. John's. The 17 remaining sorties were iceberg-reconnaissance patrols to determine the extent of iceberg danger. Portions of seven patrols supported GMES, a project that coordinates environment- and security-information providers and users. For the third year in a row, Ice Patrol participated as an end user of satellite reconnaissance through the GMES project's Polar View element, which is led by C-CORE, a global engineering firm specializing in remote sensing and geotechnical engineering. In addition to the 31 sorties, there were four logistics flights from Coast Guard Air Station Elizabeth City to maintain and repair the aircraft. **Figure 7** shows IIP's flight hours for 2005.

IRD	Deployed Days	Iceberg Patrols	Flight Hours
Pre	9	2	35.8
1	Cancelled		
2	8	2	23.0
3	Cancelled		
4	7	4	30.1
5	Cancelled		
6	6	3	25.4
7	Cancelled		
8	9	3	27.2
9	8	3	37.0
Post	4	0	19.6
Total	**51**	**17**	**198.1**

Table 1. 2005 IRD summary (Flight hours include patrol, logistics, and transit hours.)

Ice Patrol used 198.1 flight hours in 2005, a 36% decrease from 2004 (**Figure 8**). **Figure 9** compares flight hours with the number of icebergs south of 48°N since 1996. Iceberg population affects flight hours, but Figure 9 demonstrates that IIP expends a fairly consistent number of flight hours even though the number of icebergs varies significantly from year to year. Ice Patrol maintains this consistency because even a small number of icebergs passing south of 48°N can dramatically extend the geographic distribution

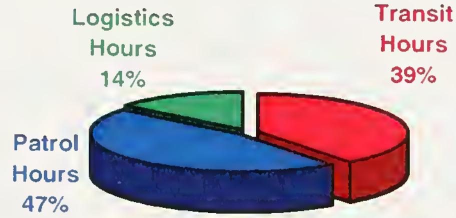


Figure 7. 2005 flight hours

of the Limit of All known Ice (LAKI), thus requiring coverage of a large area of ocean despite a sparse iceberg population.

Coast Guard aircraft provided the primary means of detecting icebergs in the vicinity of the Grand Banks. To conduct iceberg reconnaissance, IIP used a Coast Guard HC-130H long-range aircraft equipped with the Motorola AN/APS-135 Side-Looking Airborne Radar (SLAR) and the Texas Instruments AN/APS-137 Forward-Looking Airborne Radar (FLAR). Ice Patrol began using SLAR in

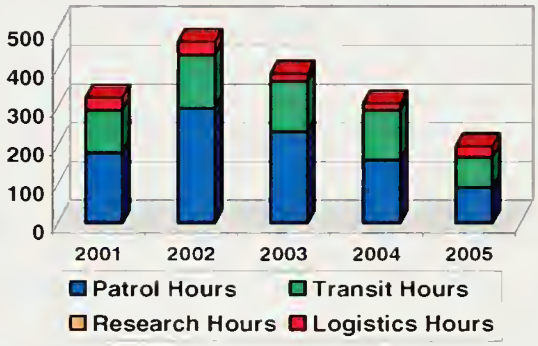


Figure 8. Breakdown of flight hours (2001-2005)

1983, FLAR in 1993, and incorporated the Maritime Surveillance System 5000 with SLAR in 2000.

After a mishap involving a U.S. Forestry Service HC-130H in 2002, comprehensive inspections identified problems with the aircraft's center wing-support structure. As a result, in 2005, significant limitations were placed on the 1500 series HC-130H aircraft, whose patrol-length maximum for IIP operations was reduced from 1,700 nm to 1,200 nm in excellent-moderate weather and 900 nm in moderate-marginal weather. These restrictions will continue until the affected airframes are inspected.

Environmental conditions on the Grand Banks permitted adequate visibility (≥10 nm) only 37% of the time during iceberg reconnaissance. Consequently, Ice Patrol relied heavily on its two airborne radar systems to detect and identify icebergs in cloud cover and

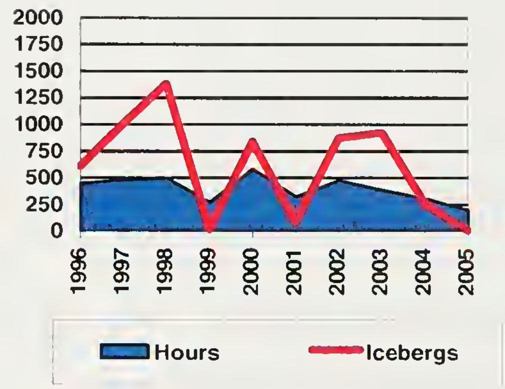


Figure 9. Flight hours versus icebergs south of 48°N (1996-2005)

fog. The combination of SLAR and FLAR enabled detection and identification of icebergs in pervasive low-visibility conditions, minimizing the flight hours necessary to accurately monitor the iceberg population. In addition, the SLAR-FLAR combination allowed IIP to use 30 nm track spacing and provide 200% radar coverage on each patrol despite poor visibility (**Figure 10**). A detailed description of IIP's reconnaissance strategy is provided at http://www.uscg.mil/lantarea/iip/FAQ/ReconnOp_10.shtml.

Identifying the various types of targets on the Grand Banks is a continual challenge for IIP reconnaissance. Frequently, visibility is poor and targets are often identified based

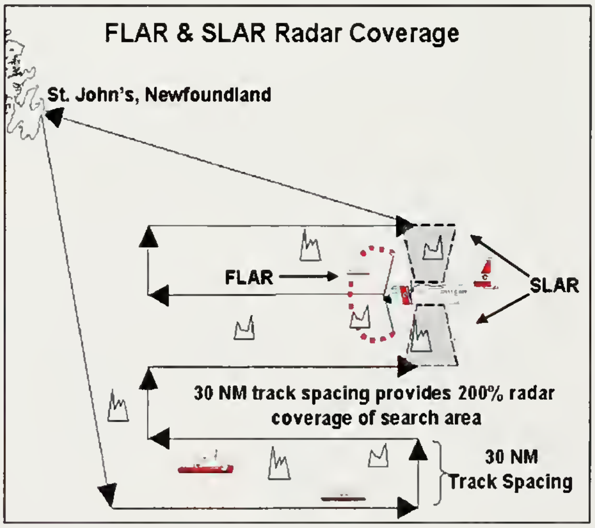


Figure 10. Radar reconnaissance plan

solely on their radar image. Both SLAR and FLAR provide valuable clues to target identity, but in most cases, FLAR's superior imaging allows definitive target identification. **Figure 11** displays the number and types of targets that reconnaissance patrols detected during 2005. Reconnaissance detachments detected a total of 35 icebergs; 9% (3) were identified with radar alone (not seen visually), while the remaining 91% (32) were identified using a combination of visual and radar information or by visual means alone.

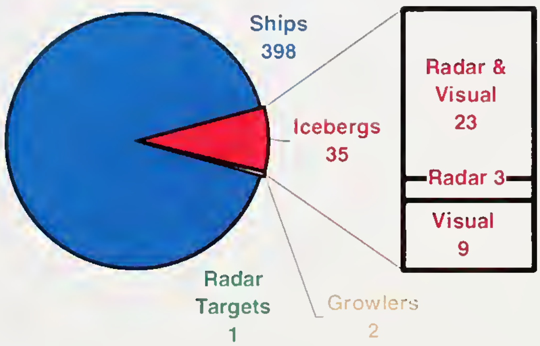


Figure 11. Breakdown of targets detected by IRDs in 2005

The Grand Banks is a major fishing area frequented by fishing vessels, ranging in size from 60 to over 200 feet. Determining whether a radar contact is an iceberg or a vessel is difficult with small vessels and small icebergs. These small contacts sometimes create similar radar returns and cannot be differentiated. Therefore, when a radar image does not present distinguishing features, Ice Patrol classifies the contact as a radar *target*.

The Grand Banks region has been rapidly developed for its oil reserves since 1997. In November 1997, Hibernia, a gravity-based oil-production platform, was set in position approximately 150 nm offshore on the northeastern portion of the Grand Banks. In addition to Hibernia, other drilling facilities—including Glomar Grand Banks, Terra Nova, and Henry Goodrich—are routinely on the Grand Banks. Consequently, this escalated drilling has increased air and surface traffic in IIP's area of responsibility, further complicating target identification. This difficulty is offset, however, by the valuable resources for detecting icebergs that increased traffic on the Grand Banks represents. As stated earlier, IIP relies heavily on information reports from mariners; their reports help IIP create ice limits that are as accurate and reliable as possible.

Oceanographic Operations

Ice Patrol's oceanographic operations peaked in the 1960s, when the U.S. Coast Guard dedicated substantial ship resources to collecting oceanographic data. Since that time, however, IIP's involvement in oceanographic surveys on the Grand Banks has declined. The decline is a result of numerous factors, three of which are the most significant. First, increased competition among various U.S. Coast Guard missions made it increasingly difficult for IIP to obtain the ship resources necessary to continue extensive oceanographic surveys. Second, because the capability and reliability of air-deployable oceanographic instruments has improved vastly, Ice Patrol can collect oceanographic data without the aid of ships. Finally, the wide availability of oceanographic information now on the Internet enables IIP personnel to focus on iceberg reconnaissance.

In 2005, IIP collected oceanographic data using AXBTs and air- and ship-deployed

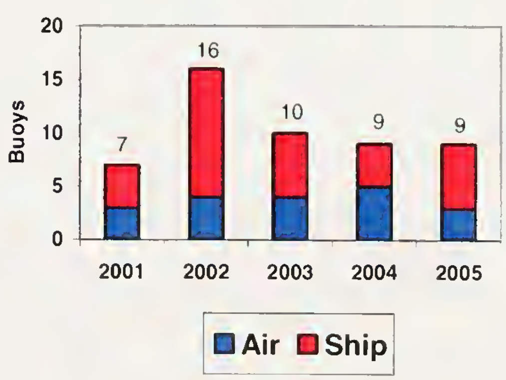


Figure 12. WOCE buoy deployments (2001-2005)

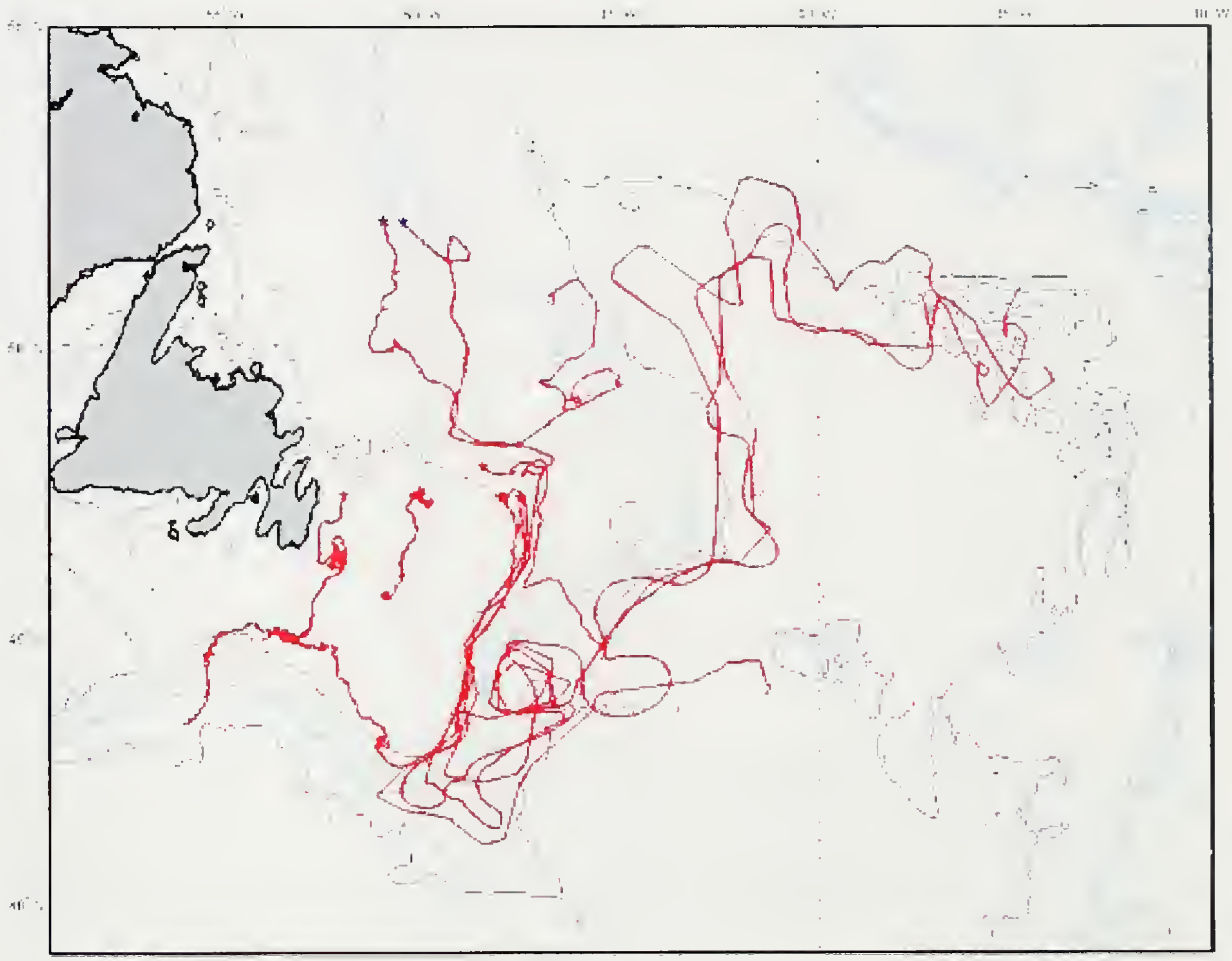


Figure 13 Composite buoy tracks. Blue stars represent drop locations of air-deployed buoys. Red stars represent ship-deployed buoys.

satellite-tracked drifting buoys. The AXBT probes measured the water-temperature profile, which helped Ice Patrol determine the location of the Labrador Current, validate temperatures from satellite-tracked drifting buoys, and obtain precise sea-surface temperatures for numerical models.

After coding AXBT data into a standard format, Ice Patrol shared it with the Canadian Maritime Atlantic Command Meteorological and Oceanographic Center—IIP's supplier of AXBT probes—and the U. S. Naval Fleet Numerical Meteorological and Oceanographic Center, where it was quality controlled and redistributed via oceanographic products.

A change in AXBT drop policy in 2002 led to a dramatic decrease in the number of AXBT drops in subsequent years. The policy requires that the patrol aircraft have visibility of the ocean surface before deploying AXBTs and that drops not interfere with reconnaissance. The frequent poor visibility on the Grand Banks therefore restricts IIP's ability to deploy AXBTs. For this reason, the policy is under review.

Satellite-tracked drifting WOCE buoys, drogued at a depth of fifteen or fifty meters, provided near real-time ocean-current information. Ice Patrol deployed WOCE buoys on the Grand Banks and in the offshore and inshore branches of the Labrador Current and used data from these buoys to modify the historical-current database within IIP's computer model.

During 2005, IIP deployed nine satellite-tracked drifting buoys, three from reconnaissance aircraft and six from Canadian Coast Guard ships (**Figure 12**). **Figure 13** depicts composite drift tracks for the buoys deployed in 2005. Detailed drifter information is provided in IIP's *2005 WOCE Buoy Drift Track Atlas*, which is available upon request.

Ice and Environmental Conditions

Introduction

The 2005 iceberg population in the western North Atlantic was so small that it did not pose a serious threat to transatlantic mariners. Thus, Ice Patrol did not provide daily warnings to mariners. During the ice year, 11 icebergs passed into the shipping lanes, placing 2005 in a tie with 1924 for the sixth-lightest year in IIP's history. This section describes the progression of the ice year and the accompanying environmental conditions.

The IIP ice year extends from October through September. The following month-by-month narrative begins as sea ice started to form along the Labrador coast in early December 2004 and concludes with 1 July 2005, when Ice Patrol stopped sending weekly ice-chart and bulletin updates to mariners. The narrative draws from several sources, including the *Seasonal Summary for Eastern Canadian Waters, Winter 2004-2005* (Canadian Ice Service, 2005); sea-ice analyses provided by the Canadian Ice Service (CIS) and the U. S. National Ice Center; sea-surface-temperature anomaly plots provided by the U. S. National Weather Service's Climate Prediction

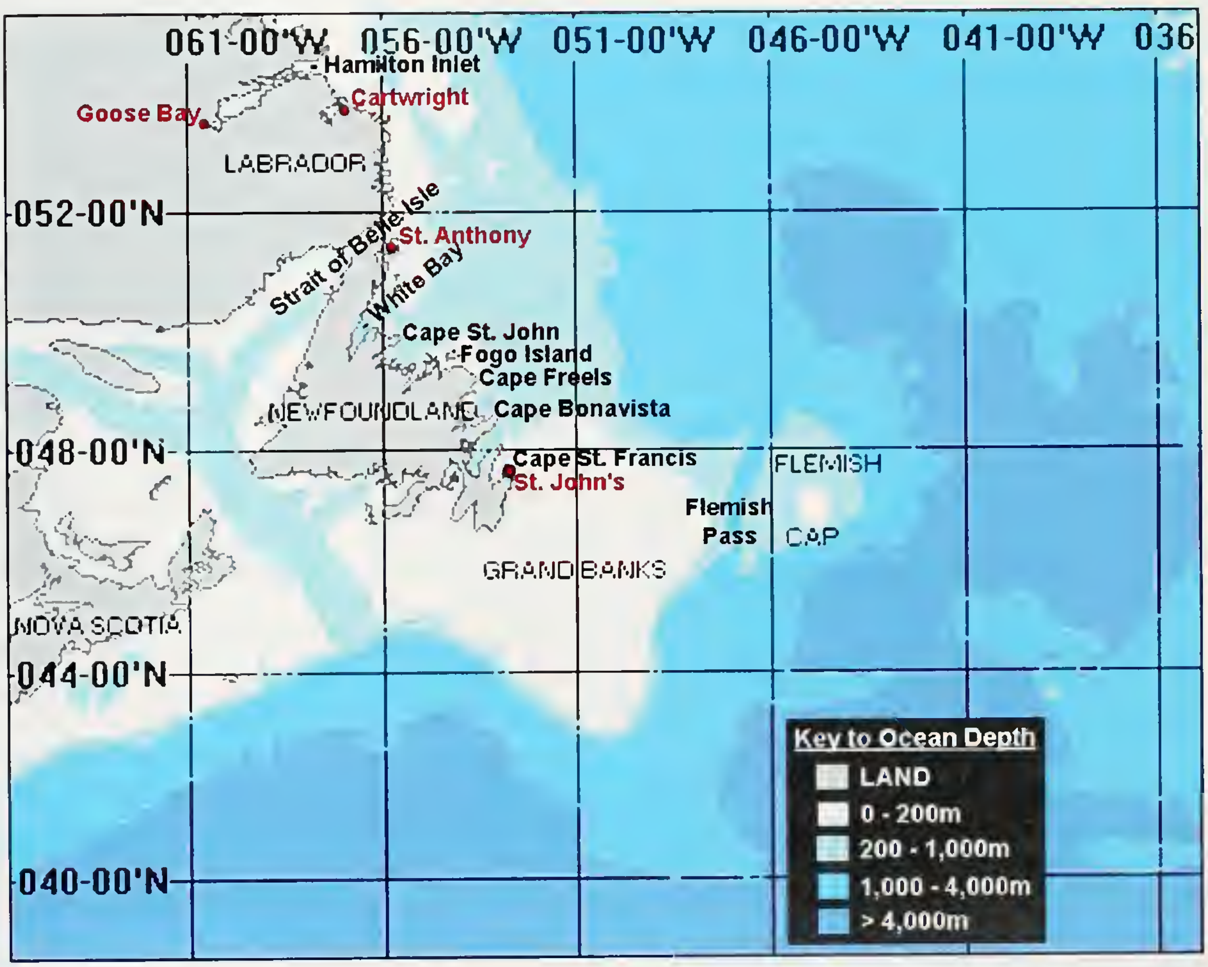


Figure 14. Grand Banks of Newfoundland

Center (National Oceanic and Atmospheric Administration [NOAA]/National Weather Service [NWS], 2006); and summaries of the iceberg data collected by Ice Patrol and CIS. Because Ice Patrol did not create daily ice limits in 2005, CIS's iceberg analyses are used to document the extent of the iceberg population from 15 February to 1 July 2005 (pages 30-39).

The progress of the 2004-2005 ice year is compared to sea-ice and iceberg observations from the historical record. The sea-ice historical data are derived from the *Sea Ice Climatic Atlas, East Coast of Canada, 1971-2000* (Canadian Ice Service, 2001), which provides a 30-year median of ice concentration at seven-day intervals for the period from 26 November to 16 July. The average number of icebergs estimated to have drifted south of 48°N for each month was calculated using 105 years (1900-2004) of Ice Patrol records (International Ice Patrol, 2006).

The preseason sea-ice forecast (Canadian Ice Service, 2004), which was issued on 3 December, predicted that

- the southern ice edge would move into the vicinity of the Strait of Belle Isle (**Figure 14**) by mid January 2005, which is two to three weeks later than normal,
- sea ice could reach as far south as Cape Bonavista during March, but that most of it would remain north of Notre Dame Bay, and
- sea ice would begin to retreat by late March.

During the first half of October 2004, CIS conducted a census of the iceberg population in Davis Strait by combining two visual-reconnaissance flights (10, 12 October) with several RADARSAT (a Canadian Earth-observation satellite) images over the period from 2 to 8 October (Desjardins, 2004). The resulting iceberg count was 451, approximately 10 of which were in the southward-moving offshore waters. This was the smallest number of offshore icebergs seen during the five years (2000-2004) in which surveys were conducted. Offshore icebergs are often the first to arrive at 48°N and are therefore the vanguard of the iceberg season. Desjardins (2004) concluded that since there were fewer icebergs in 2004 than in the four previous survey years—particularly in the offshore area—there would be a late opening to the 2005 iceberg season (defined as the date that IIP starts issuing daily warnings to mariners).

November and December 2004

Northern Labrador experienced warmer-than-normal conditions during November. For example, the mean daily air temperature at Nain, Labrador, was 1.7°C above normal (Environment Canada, 2006), and the sea-surface temperature along most of the Labrador coast was approximately 0.5°C above normal (NOAA/NWS, 2006). As a result, the southern edge of the main ice pack reached Cape Chidley—the northernmost point in Labrador—in mid December, about two weeks later than normal.

The December air temperatures in Labrador were near or slightly below normal, and the sea-surface temperature along the coast returned to normal. The southern ice edge moved persistently southward during December, arriving in the northeastern reaches of the Strait of Belle Isle at month's end, about a week later than normal but ahead of the preseason sea-ice forecast (Canadian Ice Service, 2004). The eastward ice extent along the southern Labrador coast was near normal. No icebergs passed south of 48°N during November or December.

January 2005

Much colder-than-normal air temperatures prevailed in southern Labrador during the entire month (**Figure 15**); the monthly average in Goose Bay, for example, was approximately 3.3°C below normal. Consequently, sea ice grew vigorously along the southern Labrador coast early in the month. On 10 January, Canadian Coast Guard vessels and satellite reconnaissance confirmed extensive ice development in the Strait of Belle Isle, which prompted the Canadian Coast Guard to recommend that, effective 13 January, the strait not be used by transatlantic shipping.

By mid month, the southward progress of the ice edge, which had moved south of St. Anthony, was still about a week later than normal. However, the eastward extent of the sea ice along the southern Labrador coast was approaching normal conditions. At Cartwright, the ice edge extended seaward approximately 100 nm.

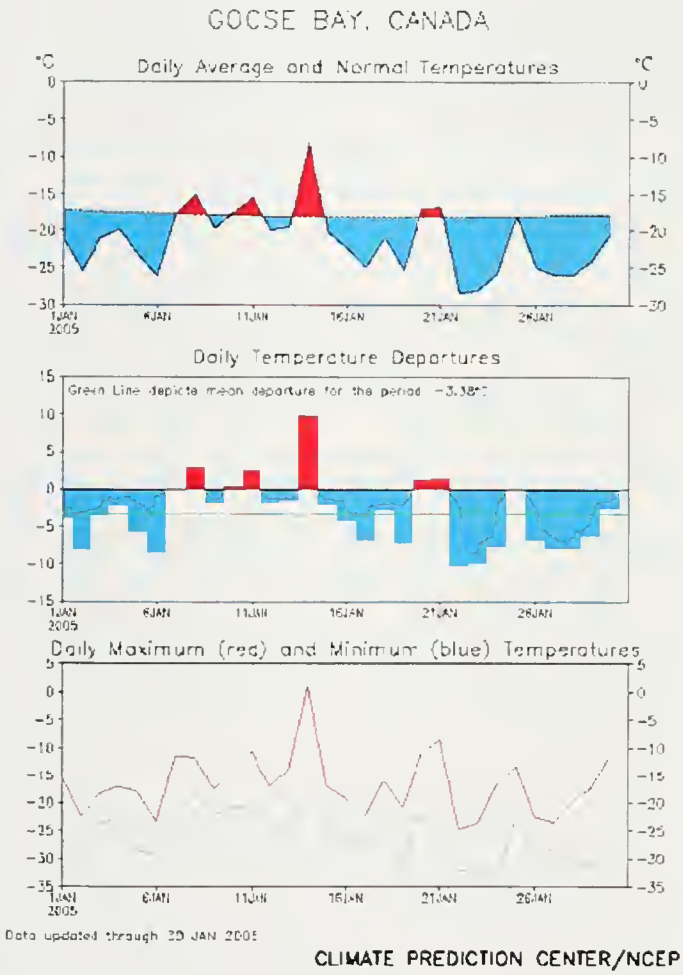


Figure 15. January 2005 air-temperature record for Goose Bay (NOAA/NWS, 2005)

During the second half of January, the southward advance of the ice edge continued at a rapid pace, but the eastward expansion slowed significantly. By month's end, the southern ice edge reached Cape Bonavista. The arrival of the southern ice edge at Cape Bonavista was slightly ahead of normal but well ahead of the CIS preseason sea-ice forecast. On the other hand, the eastward extent of the ice edge on the northeast-Newfoundland shelf was well below normal. At St. Anthony, the eastern ice edge was approximately 70 nm offshore, while in a normal year it would be over 140 nm.

On 27 January 2005, Ice Patrol deployed its preseason Ice Reconnaissance Detachment (IRD) to St. John's, Newfoundland. The intent of the IRD was to monitor the progress of icebergs toward the Grand Banks and help determine the start date for the 2005 season.

No icebergs passed south of 48°N in January; the average for the month is three.

February

Much warmer-than-normal conditions persisted in southern Labrador and Newfoundland throughout February. The daily average air temperature in Goose Bay was 4.1°C warmer than normal; in St. John's, it was 1.7°C above normal. Despite the warmer-than-normal conditions, the southern ice edge pushed steadily southward over the first half of the month, approaching to within 20 nm of St. John's, Newfoundland, by mid month. However, the eastward sea-ice edge continued to be much closer to shore than normal. At mid month, it was 100 nm east of St. Anthony,

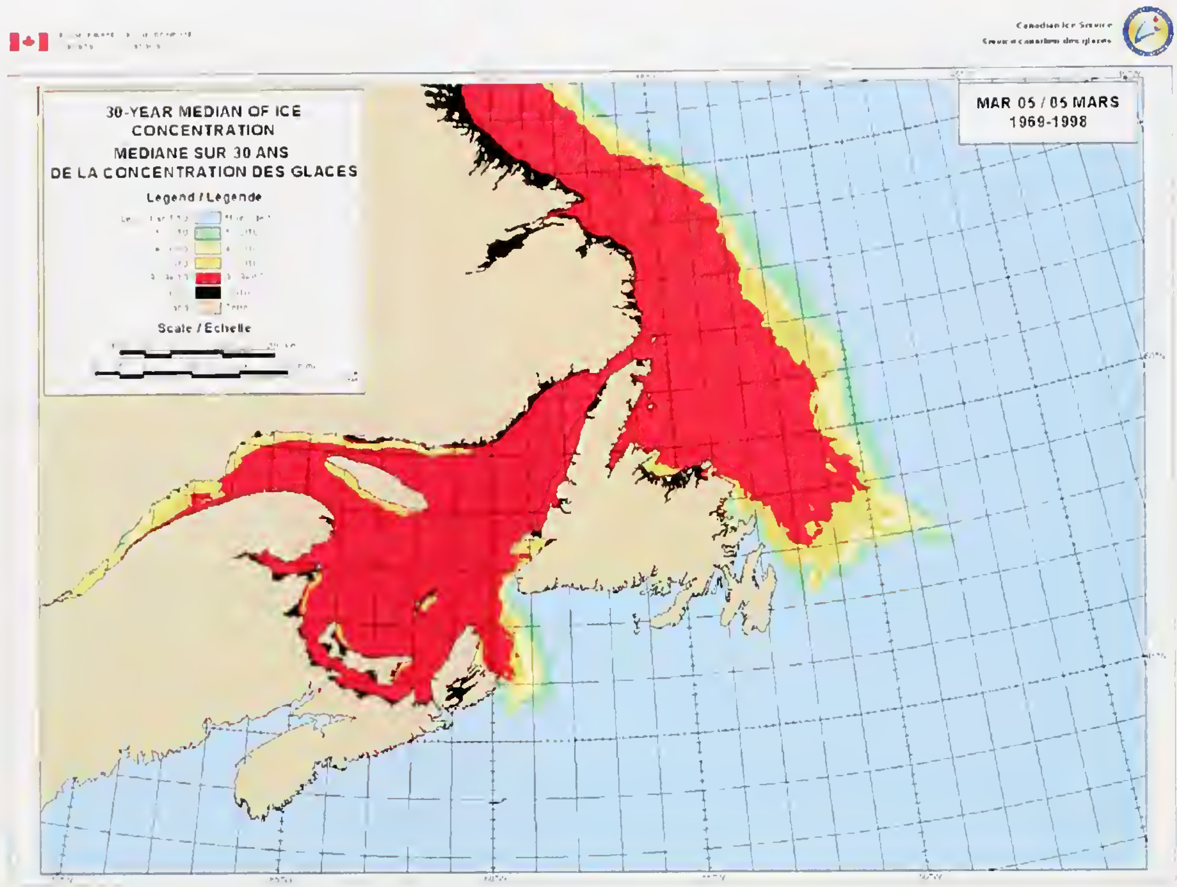


Figure 16. Median ice concentrations for 5 March (Courtesy of the Canadian Ice Service)

while in a normal year it is greater than 140 nm offshore in mid February.

There was little southward or eastward ice-edge growth during the remainder of February; the southern ice edge remained in the vicinity of 48°N and the eastern ice edge between 100 and 130 nm east of St. Anthony.

A complementary set of aerial-reconnaissance patrols in late January and early February—two by Ice Patrol's preseason IRD and three by Provincial Aerospace Limited (PAL) under contract with CIS—found a sparse iceberg population near Newfoundland and Labrador. On 1 and 2 February, the IIP aircraft conducted two reconnaissance flights, one over the sea-ice-free waters of the offshore branch of the Labrador Current between 48°N and 53°N and the other along the sea-ice edge off the Labrador coast from 53°N to 60°N. On 30 January and 5-6 February, PAL conducted extensive iceberg reconnaissance off the Newfoundland and Labrador coasts. They searched over the offshore sea-ice edge from Cape Bonavista, Newfoundland, to the southern Labrador coast at 55°N and within the sea ice along the northern Labrador coast from 55°N to 59°30′ N. The combined IIP and PAL patrols detected 11 icebergs, all north of 54°N. The results of these early flights confirmed Desjardins's (2004) prediction that the iceberg season would begin late.

No icebergs passed south of 48°N during February; the average for the month is 15.

March

Labrador remained much warmer than normal throughout March, while Newfoundland reverted to near-normal conditions.

Approximately in keeping with the CIS preseason sea-ice forecast, sea ice reached its 2005 maximum extent during the first week of March, at which time the southern ice edge was approximately at the latitude of Cape Bonavista and the eastern edge was 120 nm offshore. In a normal year, the southern ice edge is over 70 nm farther south of this latitude and the eastern edge more than 80 nm farther offshore (**Figures 16** and **17**).

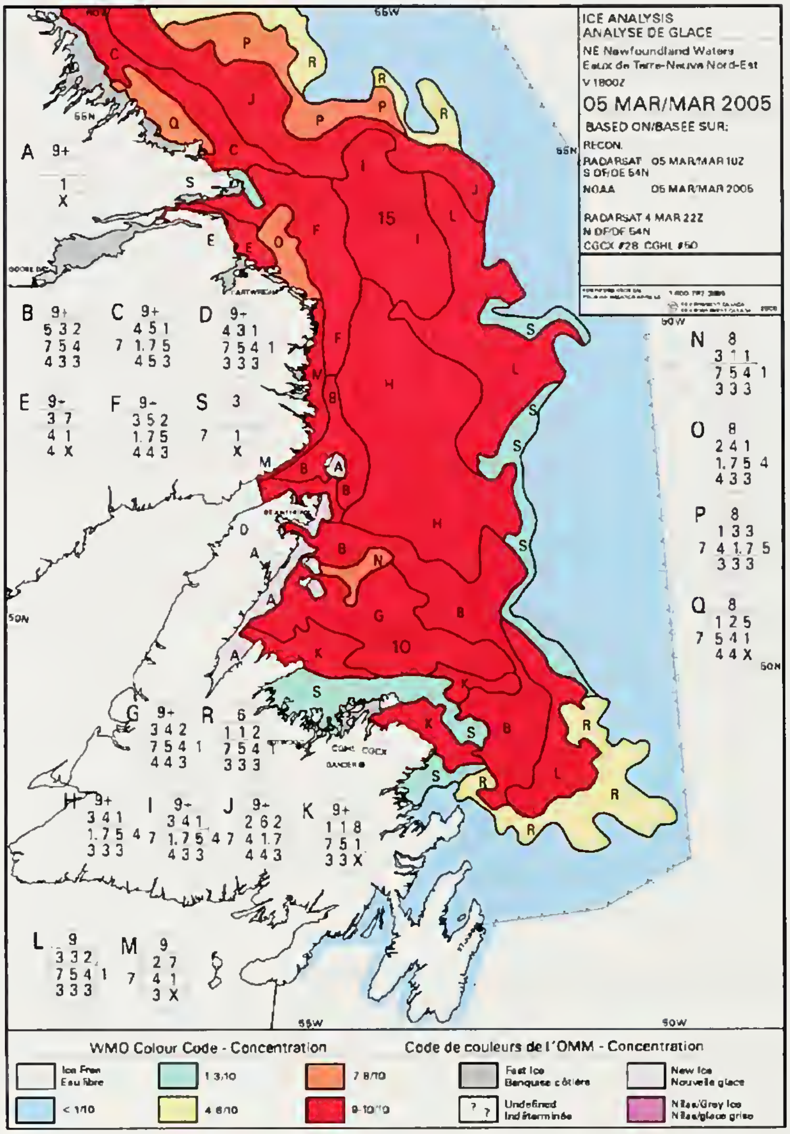


Figure 17. Sea-ice concentrations for 5 March 2005 (Courtesy of the Canadian Ice Service)

The southern ice edge remained in the vicinity of Cape Bonavista for the first half of the month, after which the sea ice began to retreat. Although sea-ice retreat commenced according to preseason predictions, its pace was faster than expected. It was fueled, in part, by an extraordinarily powerful and long-lasting North Atlantic storm that explosively intensified off Newfoundland on 12 March and then stalled. By 15 March, the low, centered at 48°N and 41°W, had deepened to 957 mbar (**Figure 18**), bringing storm-force northeast winds to east-Newfoundland waters (**Figure 19**). This complex system lingered in the area until 21 March, causing immense ice destruction and compressing the surviving ice along the coasts of northern Newfoundland and southern Labrador. By month's end, most of the northeast-Newfoundland shelf was ice free.

The reduced sea-ice extent and favorable-visibility conditions aided a series of 10 iceberg-reconnaissance flights over the period 24-29 March. Five aerial patrols by IIP, four by PAL, and one by Transport Canada searched the region between 45°30′ N and 56°30′ N. The combined flights found a very small population of icebergs, most very close to coastal Newfoundland (**Figure 20**). It was clear that this iceberg population posed no significant threat to transatlantic

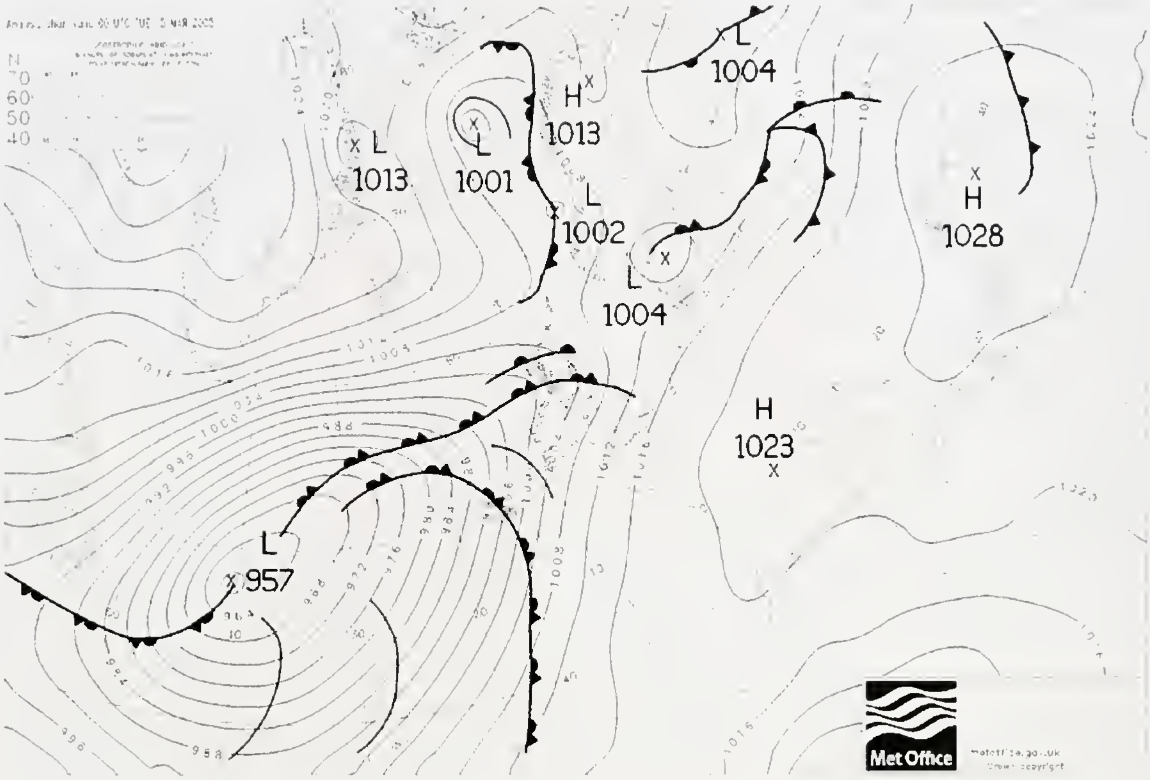


Figure 18. Sea-level pressure for 00Z 15 March 2005 (Met Office, Bracknell)

shipping. In addition, there was no substantial iceberg feeder population farther north.

One indication of how light the 2005 iceberg season was is the fact that a single iceberg was the easternmost and southernmost iceberg seen during the year. At its easternmost position (47°45.6′ N, 49°00′ W), it was seen by the Ice Patrol reconnaissance airplane on 29 March. At its southernmost position (46°52.2′ N, 50°01.2′ W), it was seen by a vessel on 5 April. These two positions are less than 100 nm apart. In a typical year, the distance between the easternmost and southernmost iceberg reports is many hundreds of miles. The easternmost (45°27.0′ N, 47°39.6′ W) and southernmost (45°55.8′ N, 47°51.6′ W) estimated iceberg positions for the season occurred on 23 and 25 March, respectively.

During March, nine icebergs drifted south of 48°N; the month's average is 61.

April

Early April was characterized by warmer-than-normal air temperatures in northern Newfoundland and Labrador. During the first two weeks of April, the daily air temperature in St. Anthony and Goose Bay averaged 2°C-3°C above normal. The sea-ice retreat from northeast-Newfoundland waters continued at a rapid pace. From 12 to 14 April, a powerful low-pressure system passed over Newfoundland, bringing strong east winds to the northern coast on the 12th. The system destroyed much sea ice and compacted what remained along the northern arm of Newfoundland and in Notre Dame Bay. By mid month, the sea-ice retreat was three to four weeks ahead of normal.

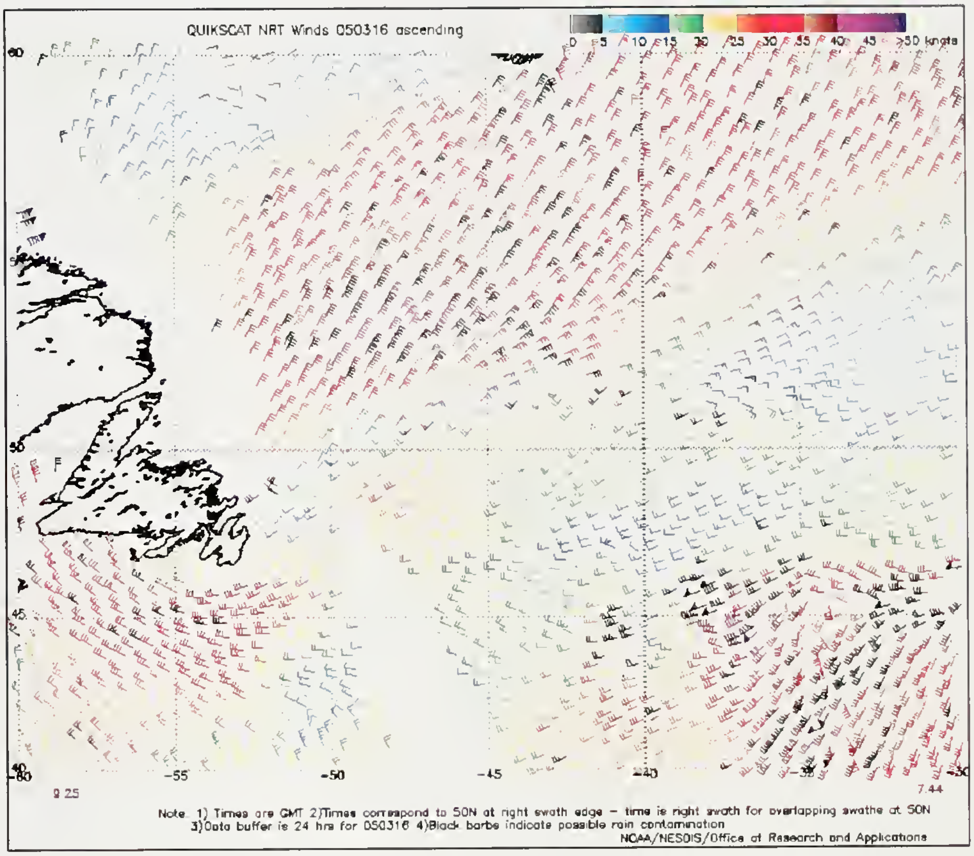


Figure 19. Surface winds for 16 Mar 2005 at 0744 UTC

Near-normal air temperatures returned to Newfoundland and southern Labrador during the second half of April. A steady southward advection of sea ice from the Labrador coast persisted for the remainder of April, maintaining the southern edge near Fogo Island until 29 April. By month's end, the sea-ice retreat was one to two weeks ahead of normal.

In April, one iceberg passed south of 48°N; the monthly average is 122.

May

The average air temperature in St. John's was near normal during the first half of May, but it was much warmer than normal in both northern Newfoundland and Labrador. St. Anthony was nearly 4°C above normal, while the daily average air temperatures in Goose Bay and Nain were 2°C-3°C above normal. Early in the month, sea ice retreated from northeast-Newfoundland waters at a pace that was three to four weeks faster than normal.

Because of the disappearance of sea ice from the Strait of Belle Isle, the Canadian Coast Guard recommended use of this passage for transatlantic voyages on 12 May 2005. With the exception of widely separated strips and patches, sea ice had cleared from the waters south of Hamilton Inlet by mid month.

At the beginning of May, there was a widely dispersed and sparse iceberg population between 48°N and 55°N (**Figure 21**). By month's end, the population south of Hamilton Inlet had dwindled to a few inshore icebergs.

One iceberg passed south of 48°N during May; the average is 150.

June

Sea ice continued its rapid retreat northward along the Labrador coast in June, aided by air temperatures that were above-normal for the month and warmer-than-normal sea-surface temperatures (**Figure 22**). By the end of the month, ice departed Labrador's coast, about three weeks earlier than normal.

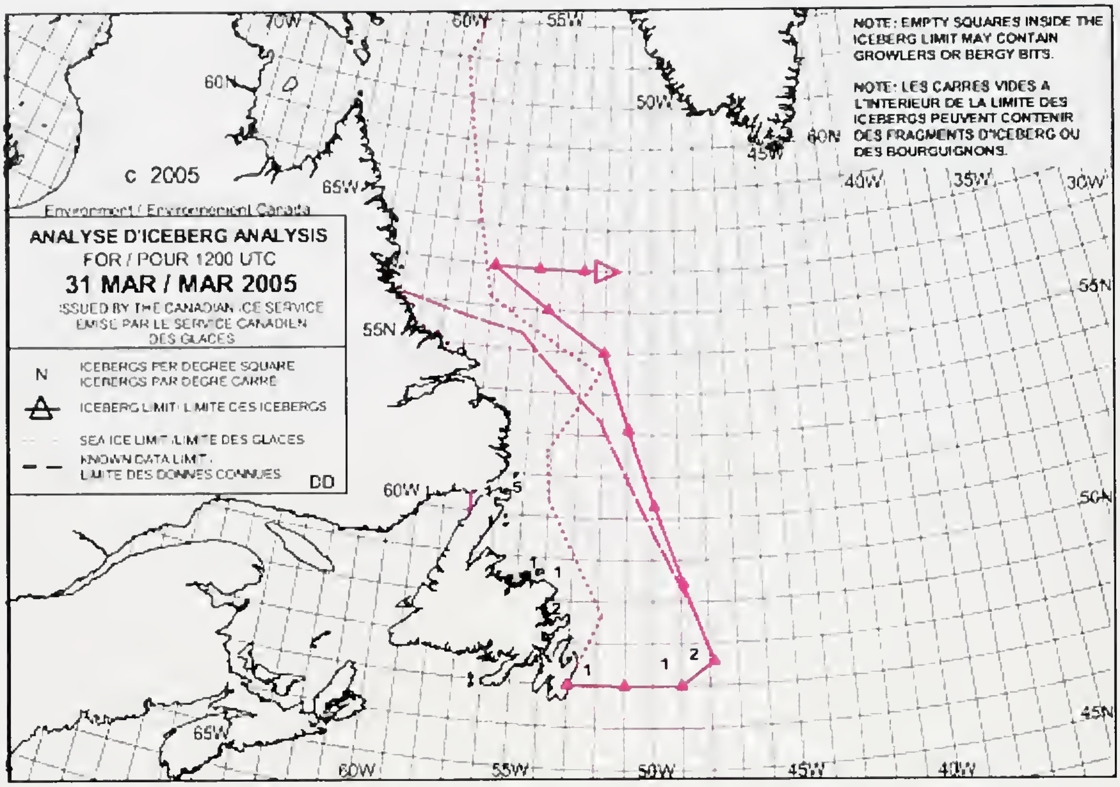


Figure 20. Iceberg distribution on 31 March 2005. There are 14 icebergs and radar targets south of 52°N. (Courtesy of the Canadian Ice Service)

Throughout June, PAL and CIS closely monitored a small iceberg population along the Labrador coast, but no icebergs approached 48°N.

Ice Patrol's last 2005 Ice Reconnaissance Detachment returned from Newfoundland on 8 June.

Discussion

The 2005 ice season saw 11 icebergs pass south of 48°N, tying 1924 as the sixth-mildest ice year in Ice Patrol's history.

There were no clear and consistent early-season indicators for the low iceberg count. The usual indicators of ice-season severity—preseason iceberg surveys, development of sea ice along the Labrador and Newfoundland coasts, and the North Atlantic Oscillation (NAO) index—offered mixed signals.

Both the October 2004 iceberg census conducted by CIS in Davis Strait and the combined IIP and PAL flights in late January and early February gave evidence that there were few icebergs upstream of 48°N. The CIS census found 10 icebergs in the offshore area, while the IIP and PAL patrols detected 11 icebergs, all north of 54°N. The results of these early flights confirmed that the prediction of a late start to the iceberg season (Desjardins, 2004) was correct and pointed to a light upcoming iceberg season. It is almost certainly a coincidence, however, that the number of icebergs found in the preseason surveys (10 and 11) and the total 2005 iceberg count (11) were nearly the same. Nevertheless, the message from the surveys was clear: a light season was imminent.

On the other hand, sea-ice development in Newfoundland and Labrador waters was near normal during freeze-up in

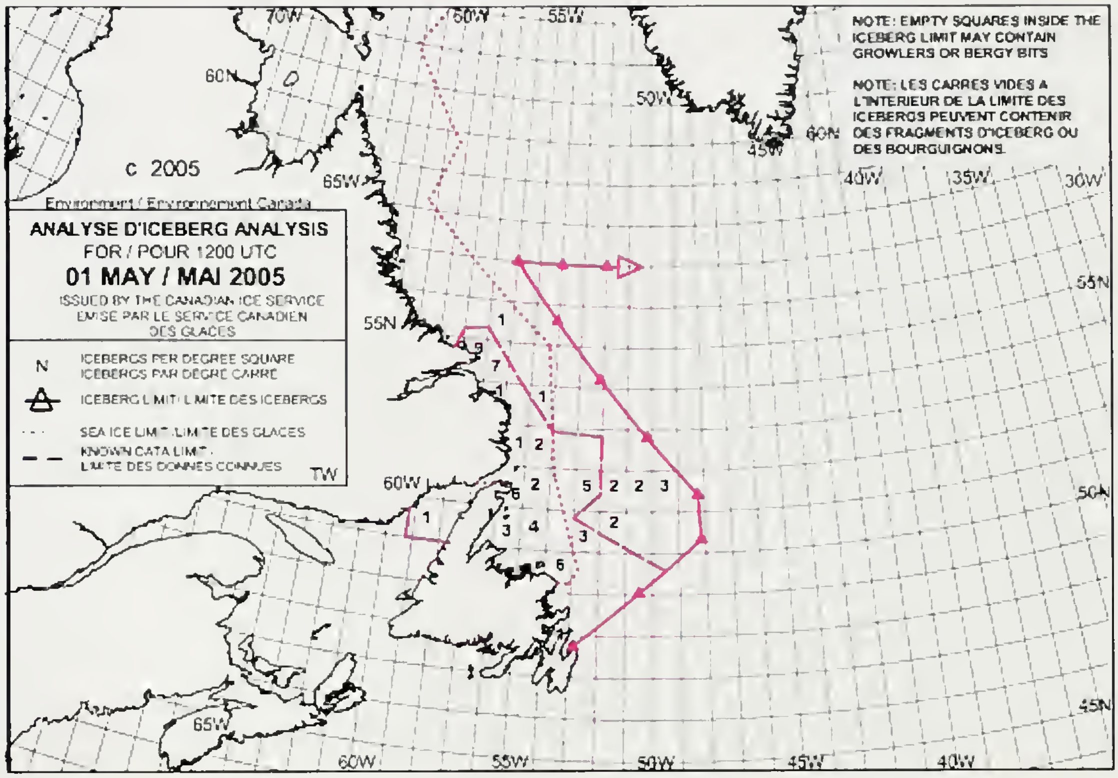


Figure 21. Iceberg distribution on 1 May 2005. There are 61 icebergs and radar targets south of 55°N. (Courtesy of the Canadian Ice Service)

2005 (**Figure 23**). The late winter and spring sea-ice extent off Labrador and Newfoundland has long been thought to play a major role in the number of icebergs moving southward into the shipping lanes, so that, for example, extensive sea ice leads to numerous icebergs. Edward H. Smith (1926) described sea ice as acting like a fender (others have called it an ice fence) on the shoreward side of the Labrador Current, preventing icebergs from moving close to shore and there grounding, thus allowing them to drift farther south and into the shipping lanes. Sea ice also protects icebergs from wave action—a major source of deterioration—and, of course, signals the presence of cold water, which also slows deterioration.

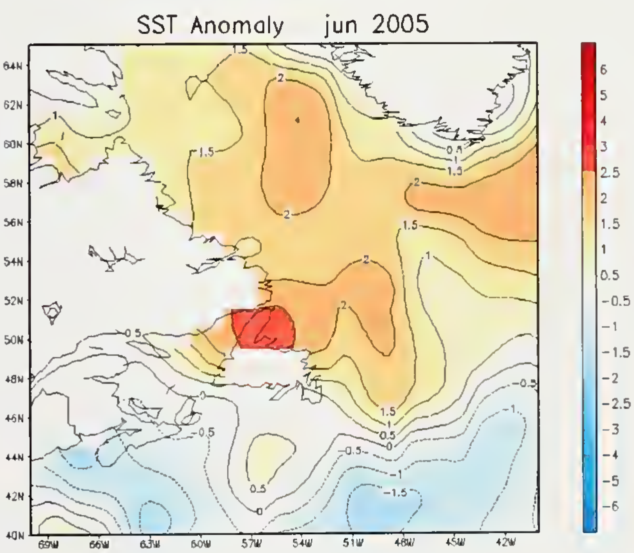


Figure 22. Sea-surface-temperature anomaly for June 2005 in degrees Celsius (NOAA/NWS, 2006)

Peterson, Prinsenberg, and Langille (2000) explored the relationship between sea ice and iceberg populations. They found that the "annual number of icebergs drifting south of 48°N is most strongly correlated with sea ice extent off Newfoundland between 47 and 52°N from

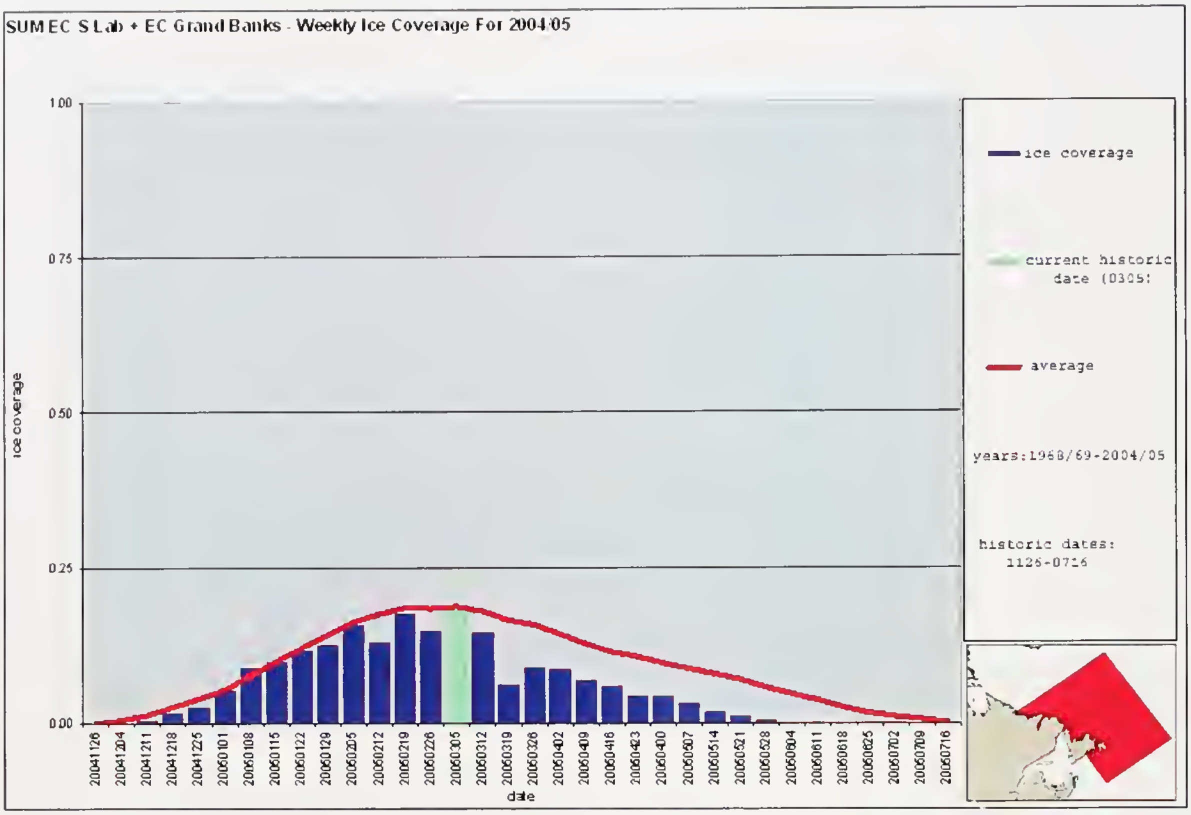


Figure 23. Normalized ice coverage in east-Newfoundland waters in 2005 (Canadian Ice Service, 2005)

Apr 1-June 1 (r=0.82)." Peterson (2004) used the relationship between sea ice and iceberg populations to develop a long-range iceberg-forecasting system. The early part of 2005 presented a formidable challenge to the forecast technique. Based on the near-normal early sea-ice growth, the forecast system predicted a medium (near normal) population of icebergs for February and March (I.K. Peterson, personal communication, April 2006), yet a sparse population was observed.

Finally, the winter 2005 (December 2004-March 2005) North Atlantic Oscillation index was weakly positive, 0.12 (Hurrell, 2006), offering no evidence that an unusually light iceberg year was forthcoming. Hurrell (2006) calculates the NAO index using the difference of normalized sea-level pressure between Lisbon, Portugal, and Stykkisholmur/Reykjavik, Iceland. The NAO, the dominant mode of winter atmospheric variability in the North Atlantic, fluctuates between positive and negative phases. The positive phase is associated with meteorological conditions that favor the movement of icebergs into the shipping lanes. These conditions include strong northwest winds along the Labrador coast, which bring colder-than-normal air temperatures and greater-than-normal sea-ice extent. In addition, the persistent northwest winds promote southward iceberg movement. Warmer-than-normal conditions and less extensive sea ice off the Labrador coast are associated with the negative NAO phase. The 0.12 NAO index value was essentially neutral—that is, the atmospheric conditions were neither very favorable nor unfavorable to the southward transport of icebergs into the North Atlantic shipping lanes.

References

Bancroft, G. P. (2005, August). Marine Weather Review—North Atlantic Area, January to April 2005 [Electronic version]. *Mariners Weather Log*, *49*(2).

Canadian Ice Service. (2001). *Sea Ice Climatic Atlas, East Coast of Canada, 1971-2000.* Ottawa: Kaice-Tec Reproduction Limited.

Canadian Ice Service. (2004). *Seasonal Outlook, Gulf of St. Lawrence and East Newfoundland Waters, Winter 2004-2005.* Ottawa: Author.

Canadian Ice Service. (2005). *Seasonal Summary for Eastern Canadian Waters, Winter 2004-2005.* Ottawa: Author.

Desjardins, L. (2004). *2005 East Coast Seasonal Outlook.* Presented at the International Ice Patrol Annual Conference, New London, CT.

Environment Canada. (2006). *National Climate Data and Information Archive.* Retrieved March 3, 2006, from http://www.climate.weatheroffice.ec.gc.ca

Hurrell, J. (2006). *Winter (Dec-Mar) Station Based NAO Index.* Retrieved January 30, 2006, from the National Center for Atmospheric Research, Climate and Global Dynamics Division Web site: http://www.cgd.ucar.edu/cas/jhurrell/indices.data.html#naostatdjfm

International Ice Patrol. (2006). *Ice Patrol's Iceberg Counts.* Retrieved January 26, 2006, from http://www.uscg.mil/lantarea/iip/General/icebergs.shtml

NOAA/NWS. (2005). *Global Temperature Time Series.* Retrieved January 31, 2005, from the National Oceanic and Atmospheric Administration/National Weather Service Web site http://www.cpc.ncep.noaa.gov/products/global_monitoring/temperature/ecanada_30temp.shtml

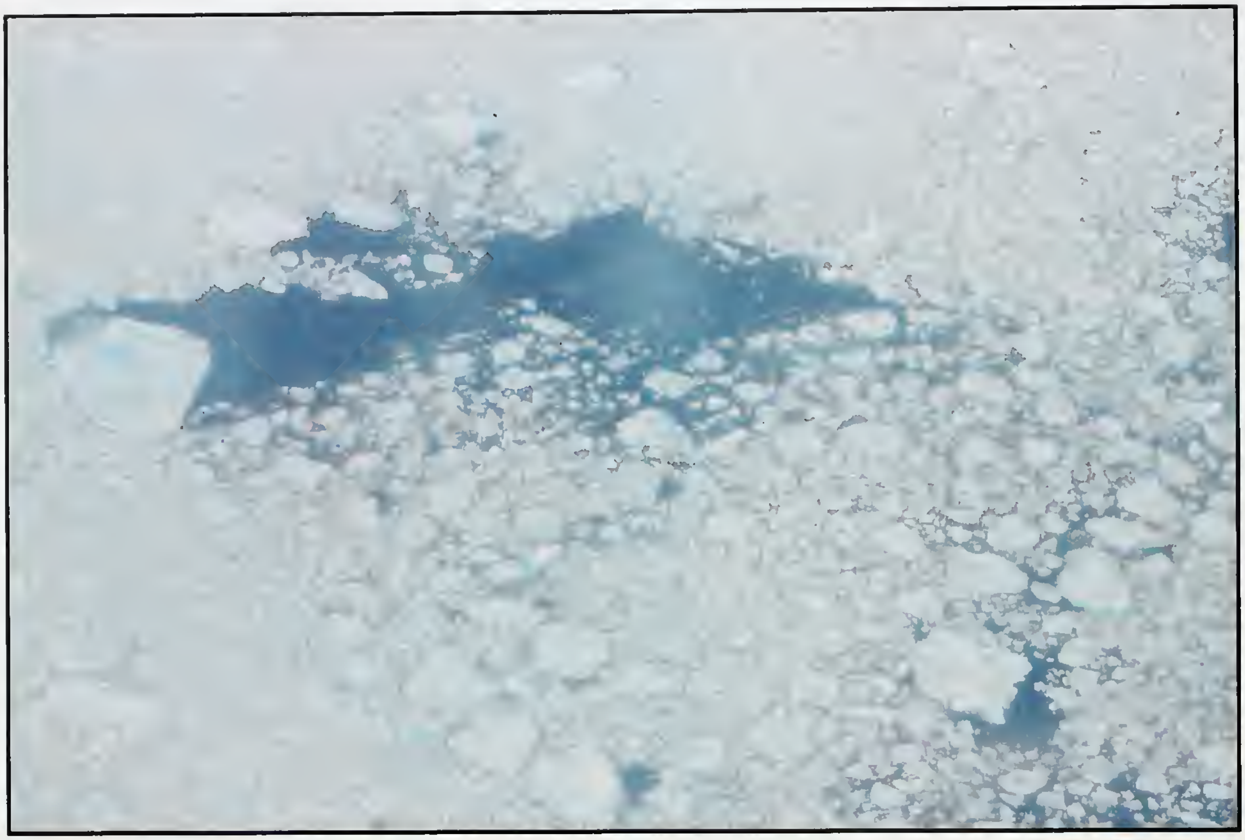
NOAA/NWS. (2006). *NOAA Operational Model Archive Distribution System.* Retrieved March 3, 2006, from the National Oceanic and Atmospheric Administration/National Weather Service Web site: http://nomad3.ncep.noaa.gov

Peterson, I. K. (2004). Long-Range Forecasting of the Iceberg Population on the Grand Banks. *Proceedings of the Fourteenth International Offshore and Polar Engineering Conference*, Toulon, France, May 23-28, 2004, Vol. I, pp. 831-836.

Peterson, I. K., Prinsenberg, S. J., & Langille, P. (2000). *Sea Ice Fluctuations in the Western Labrador Sea (1963-1998).* Can. Tech. Rep. Hydrogr. Ocean Sci. 208: v+51 p.

Smith, E. H. (1926). Weather—A Brief Review of the 1926 Ice Season. *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean*, Bulletin No. 15, 31-48.

Monthly Sea-Ice Charts



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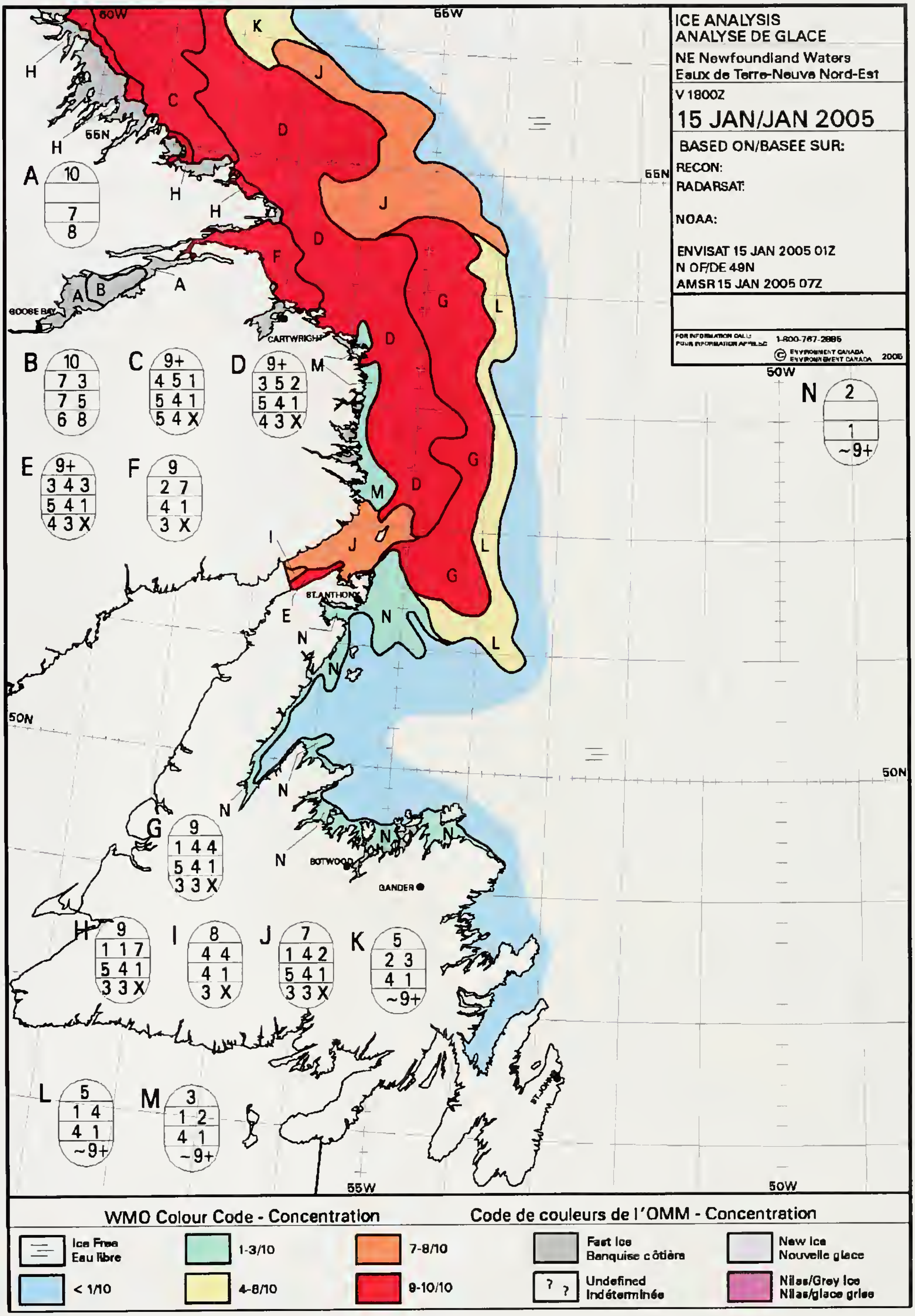
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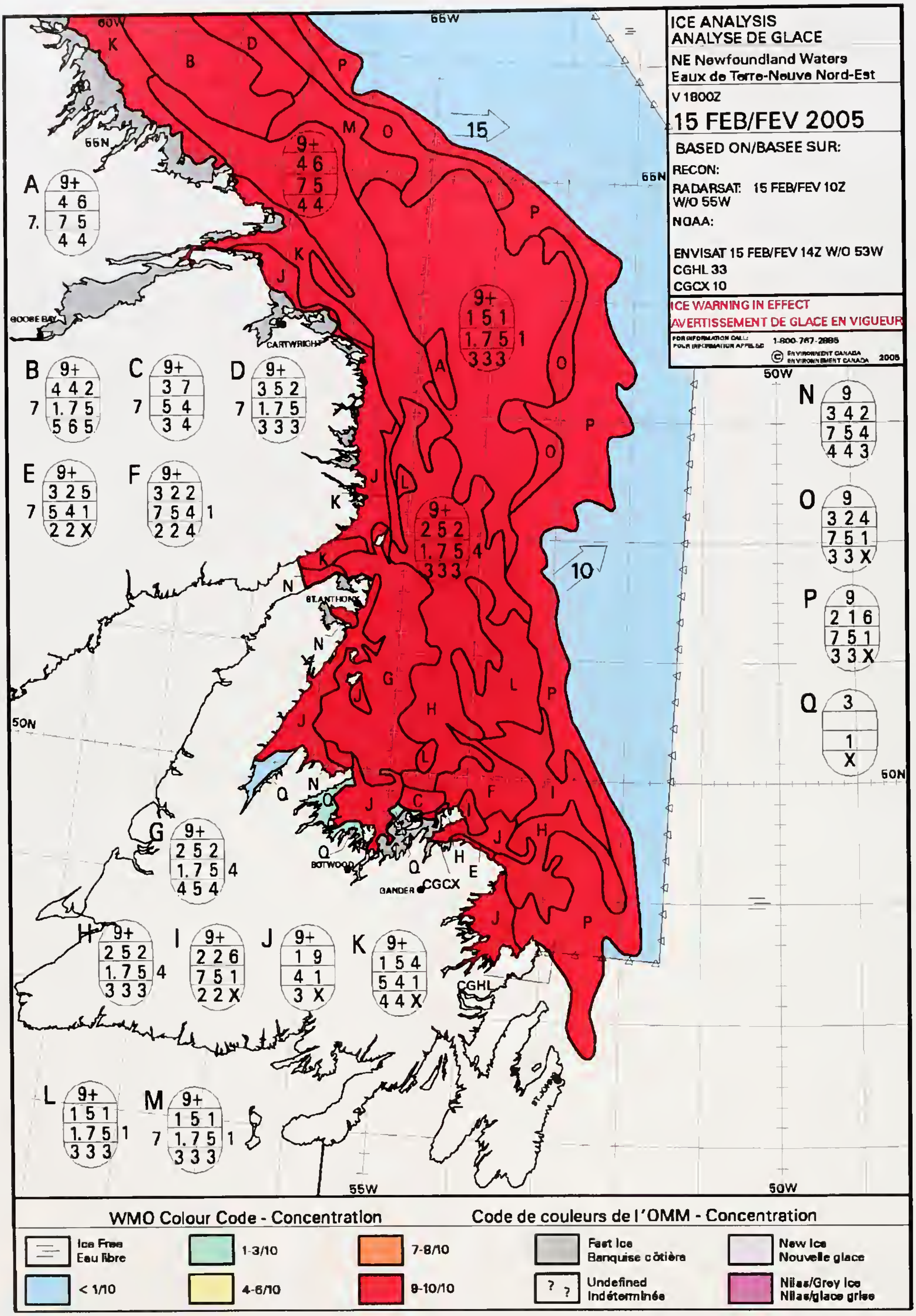
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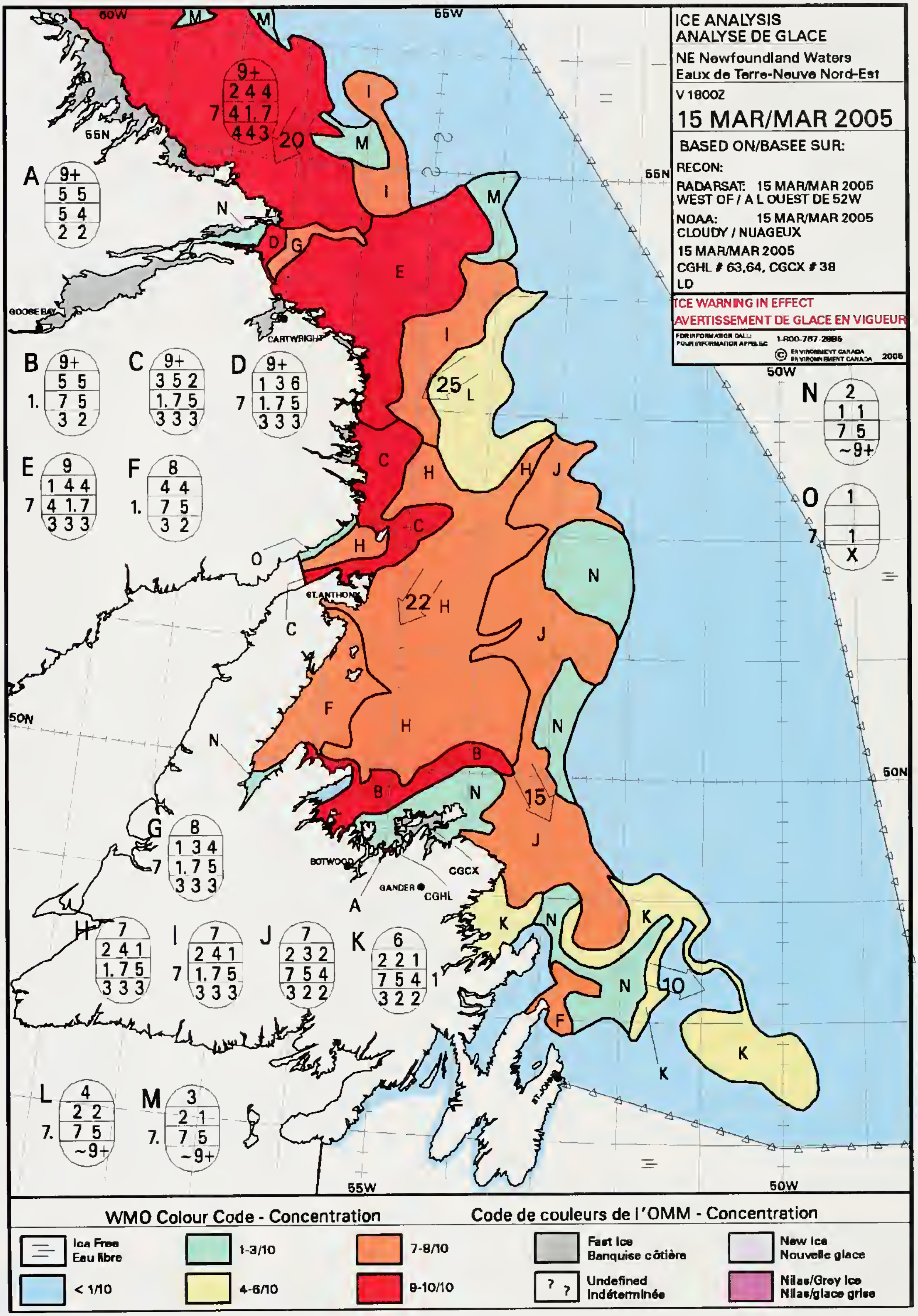
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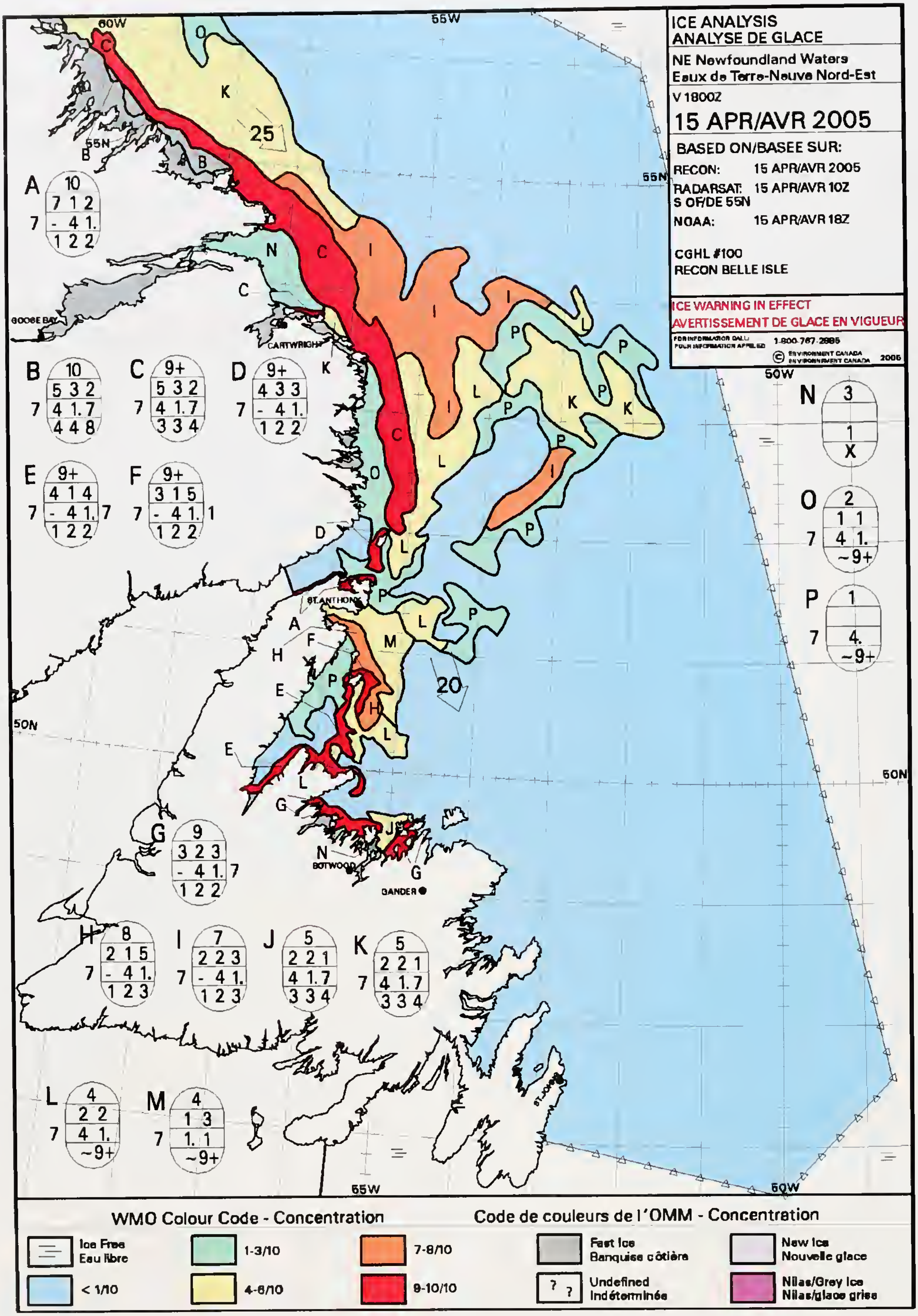
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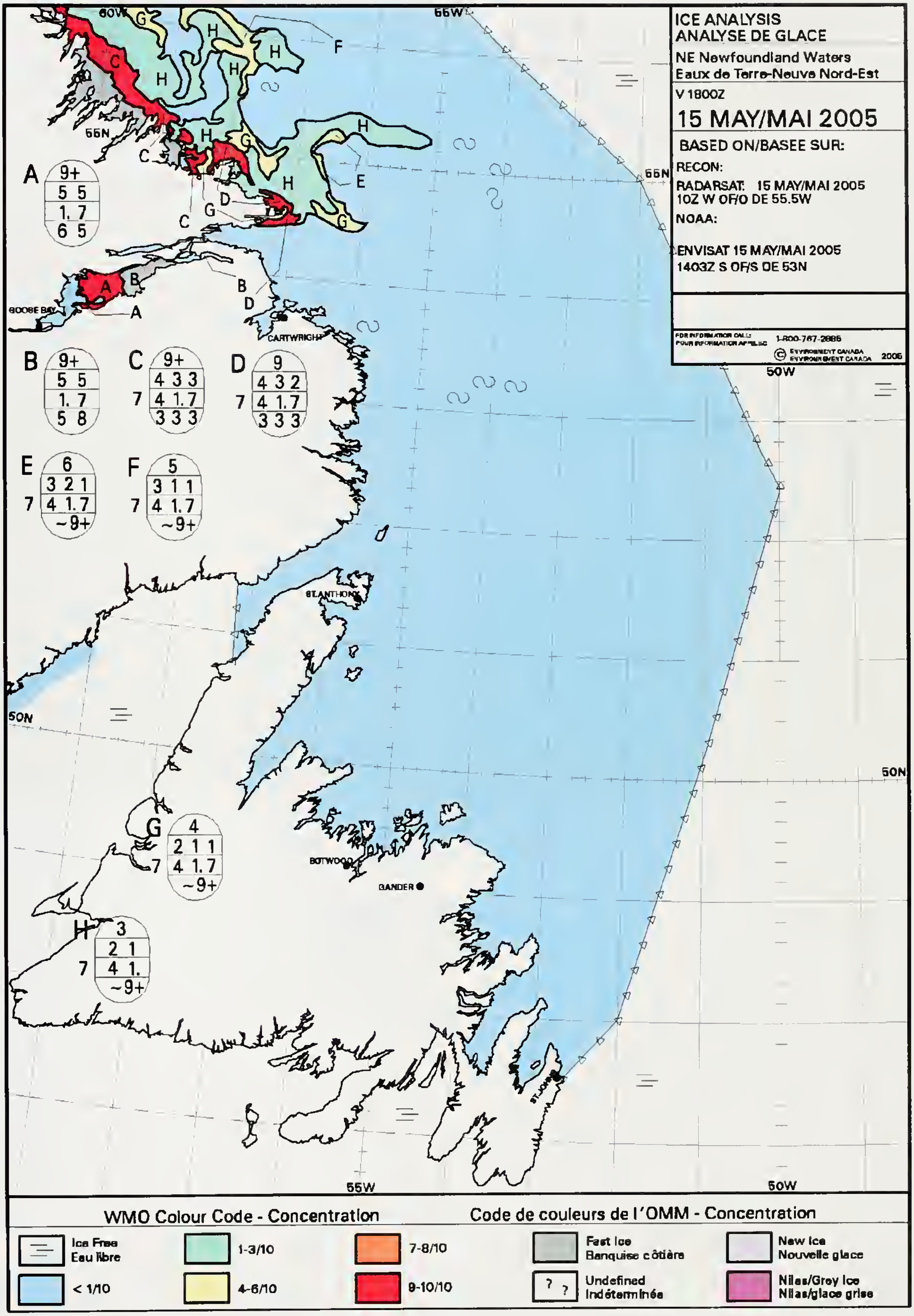
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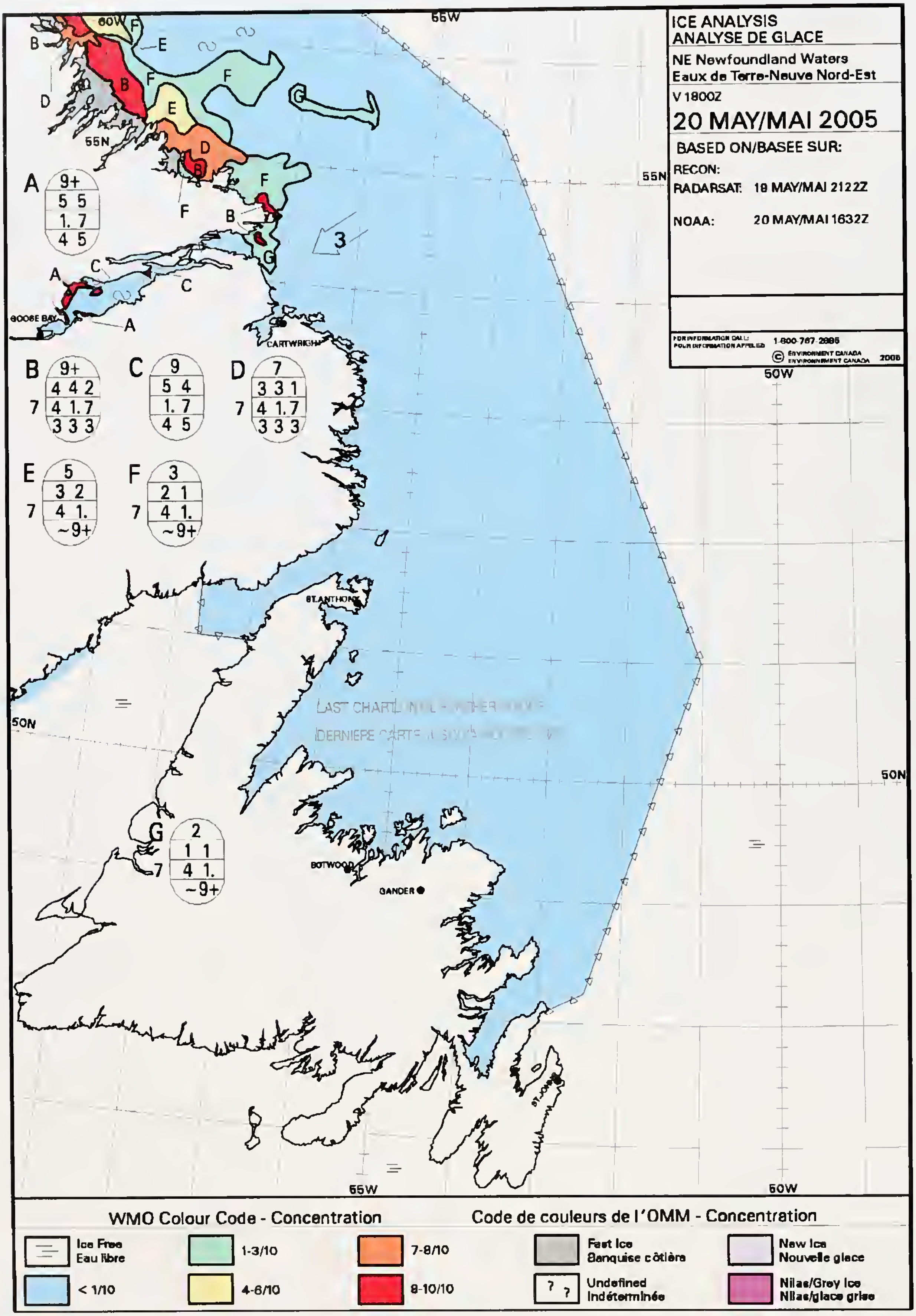
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Fast Ice
Banquise côtière
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Nilas/Grey Ice
Nilas/glace grise

Biweekly Iceberg Charts

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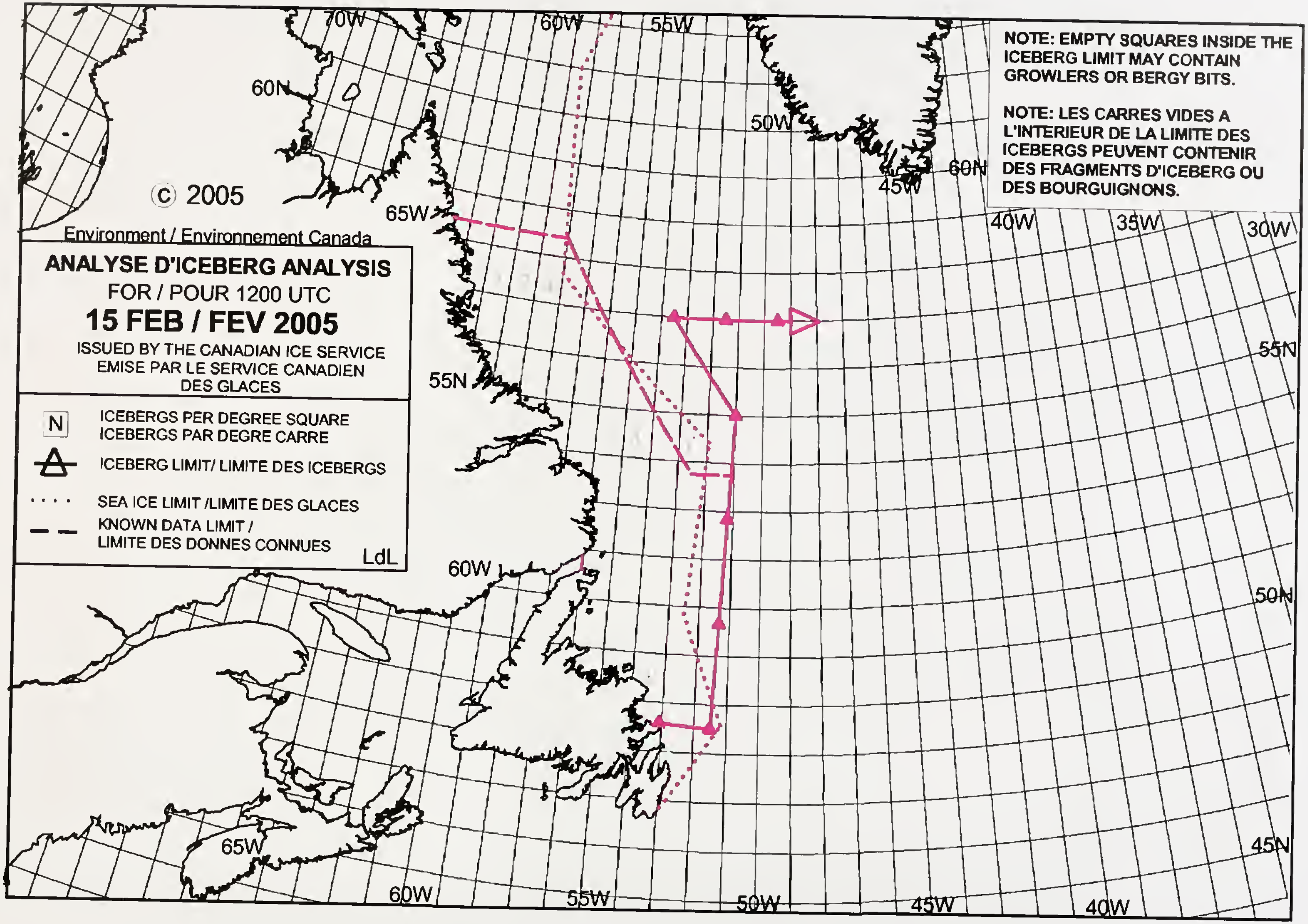
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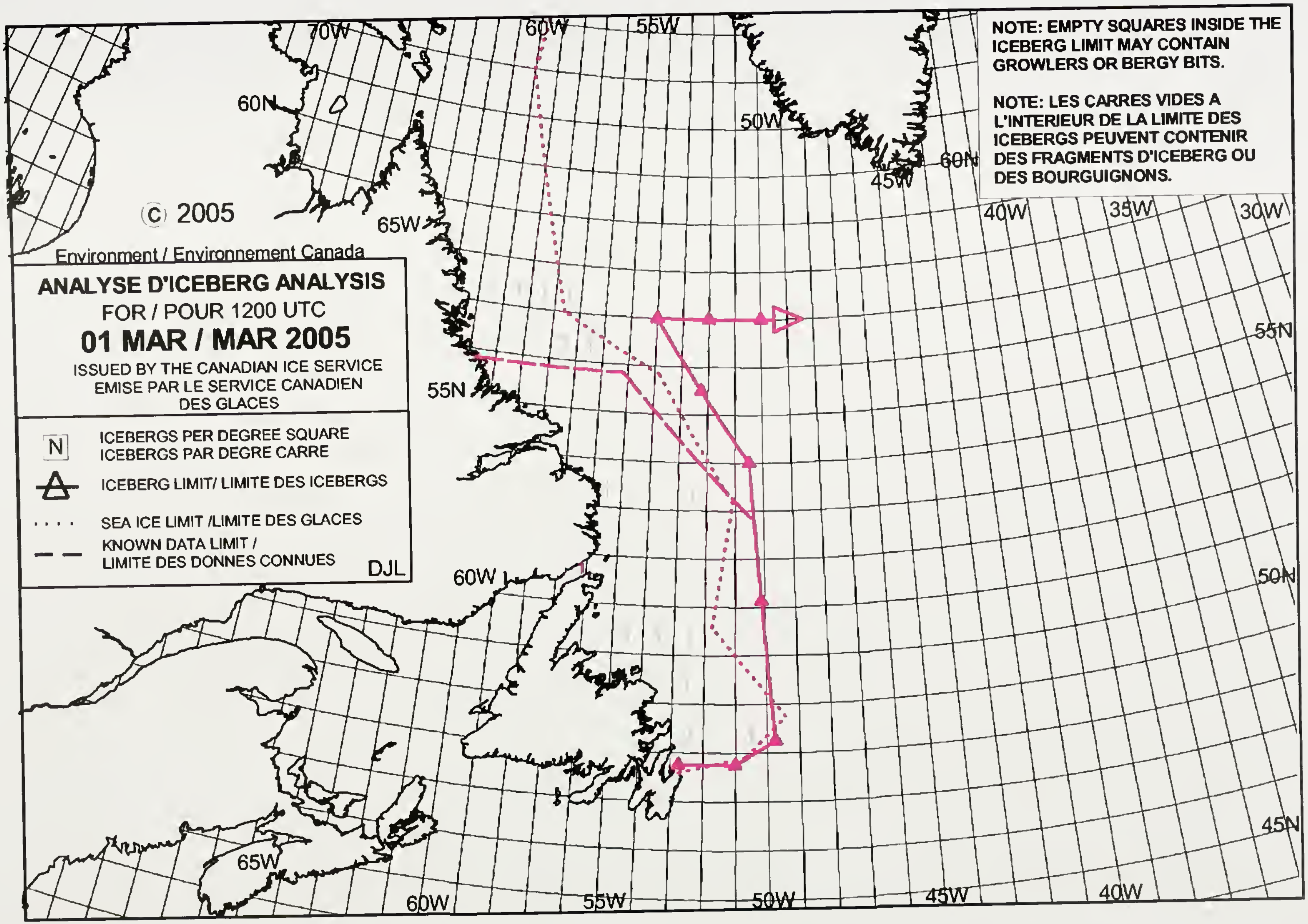

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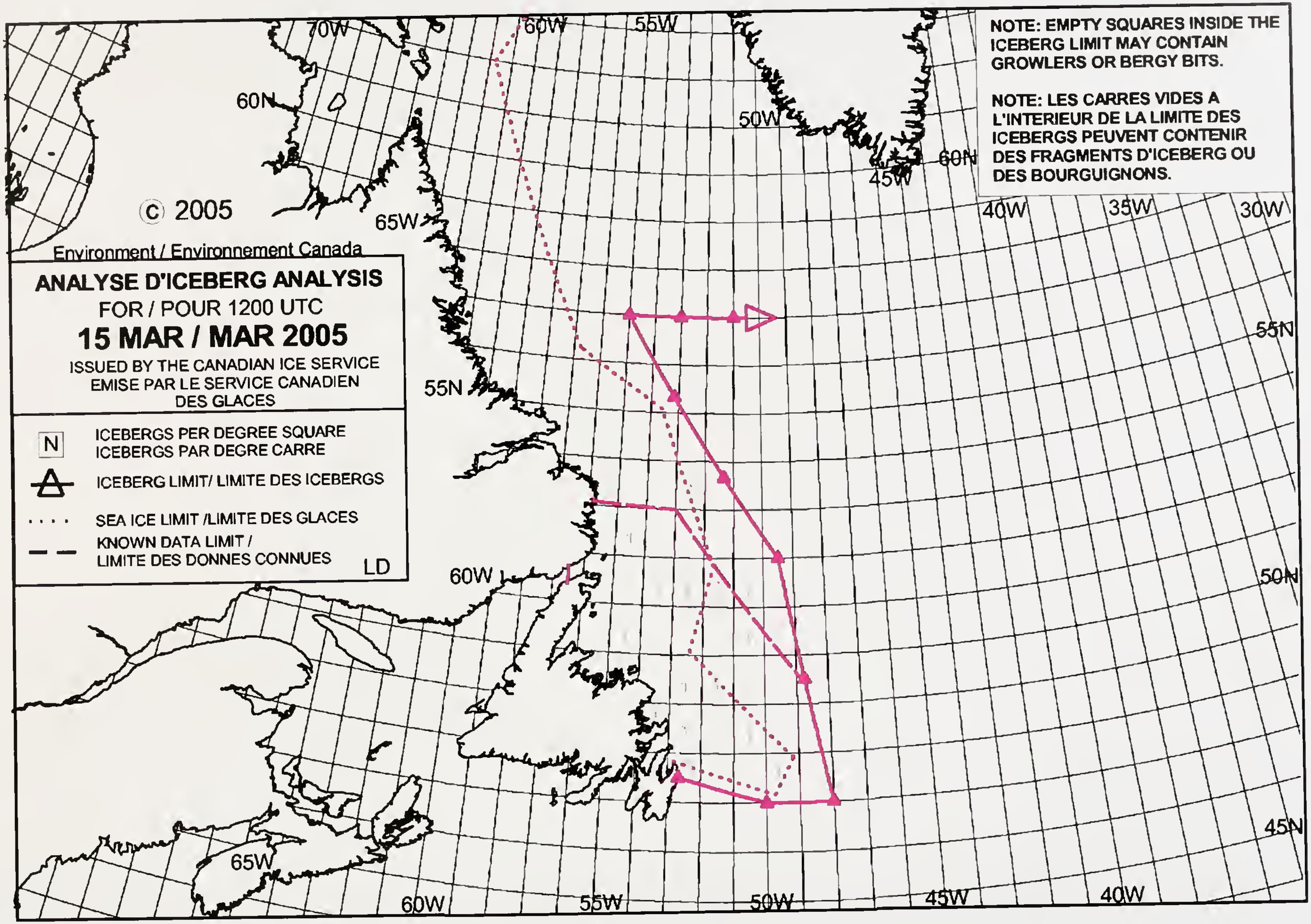
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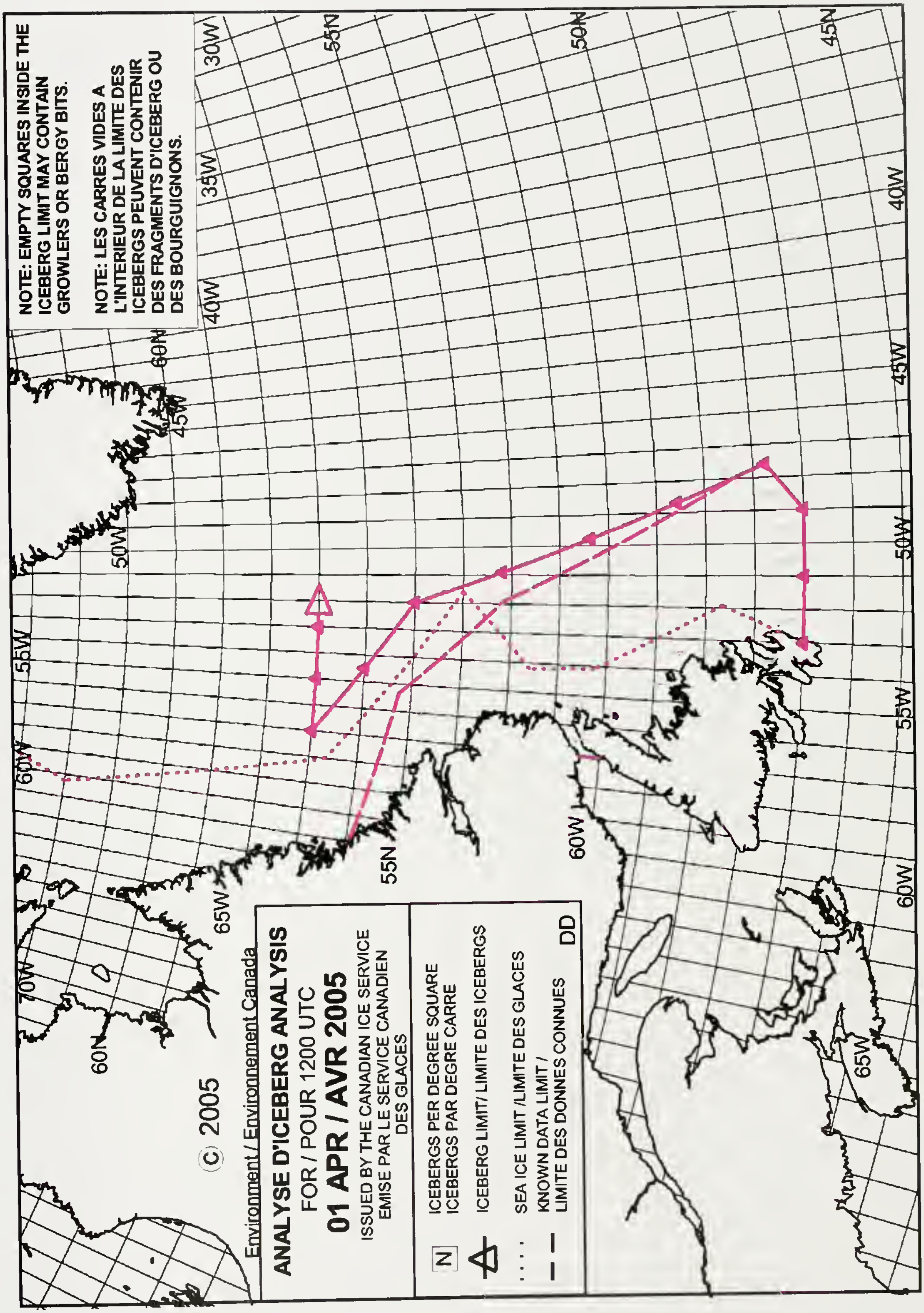
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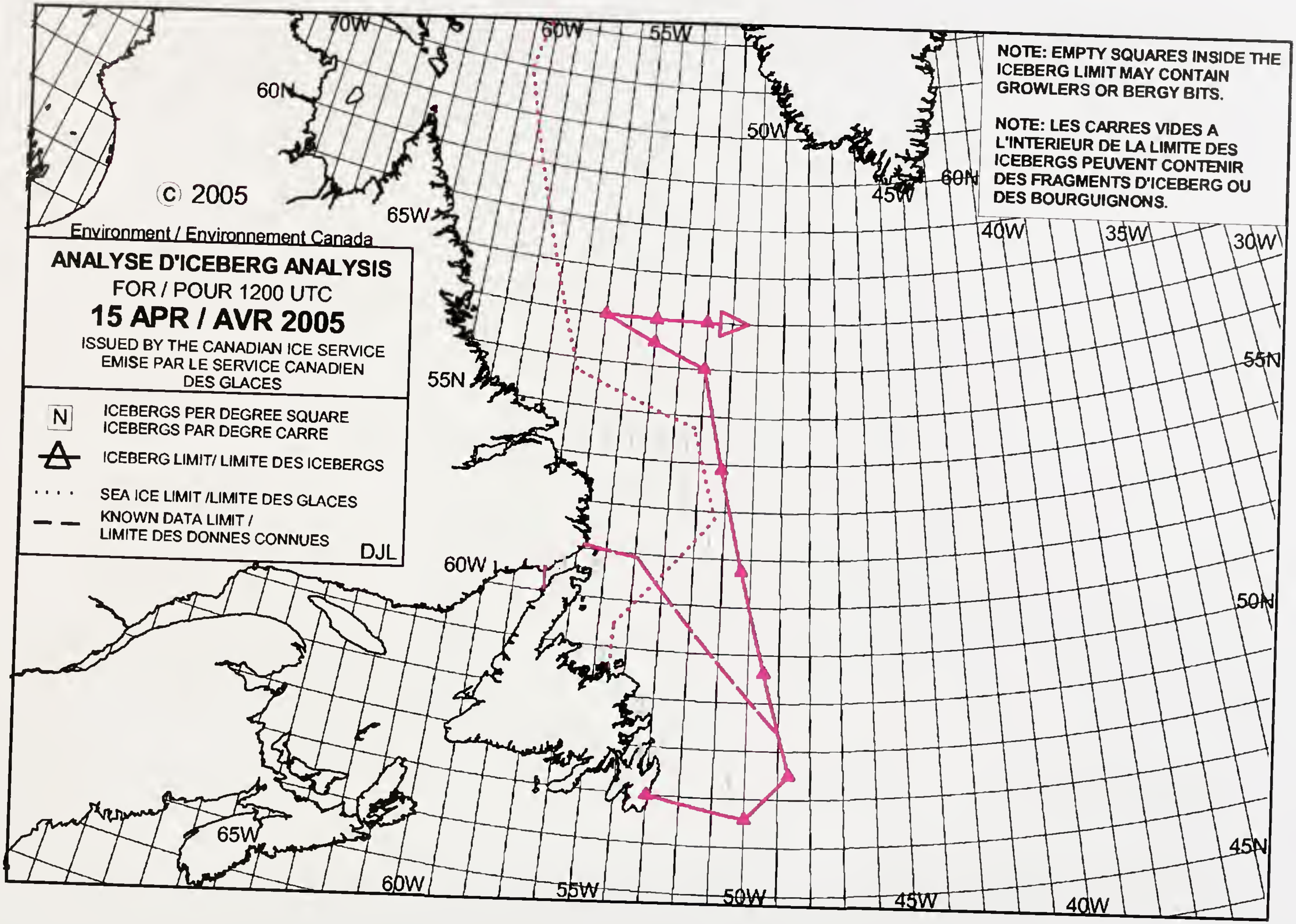

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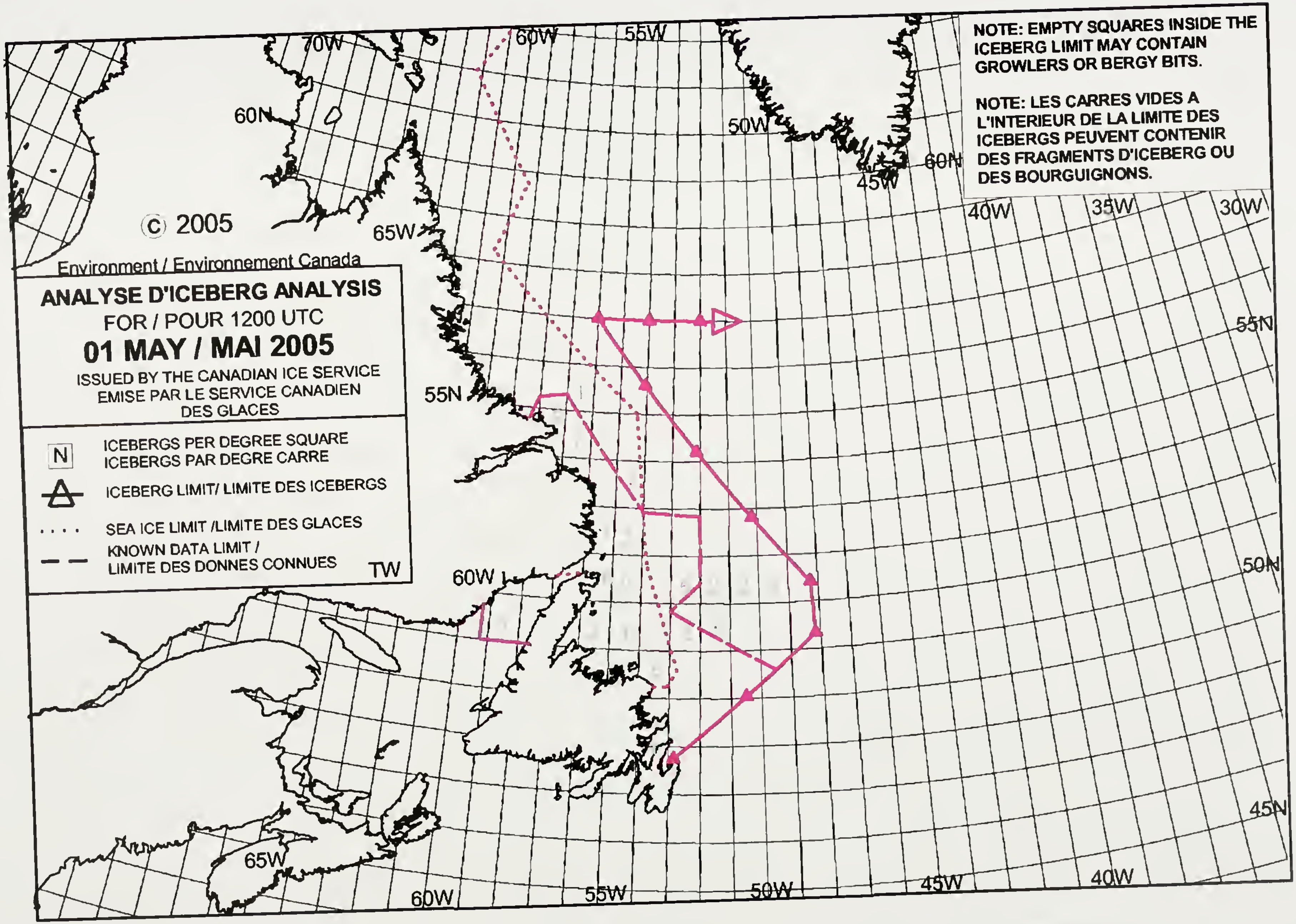
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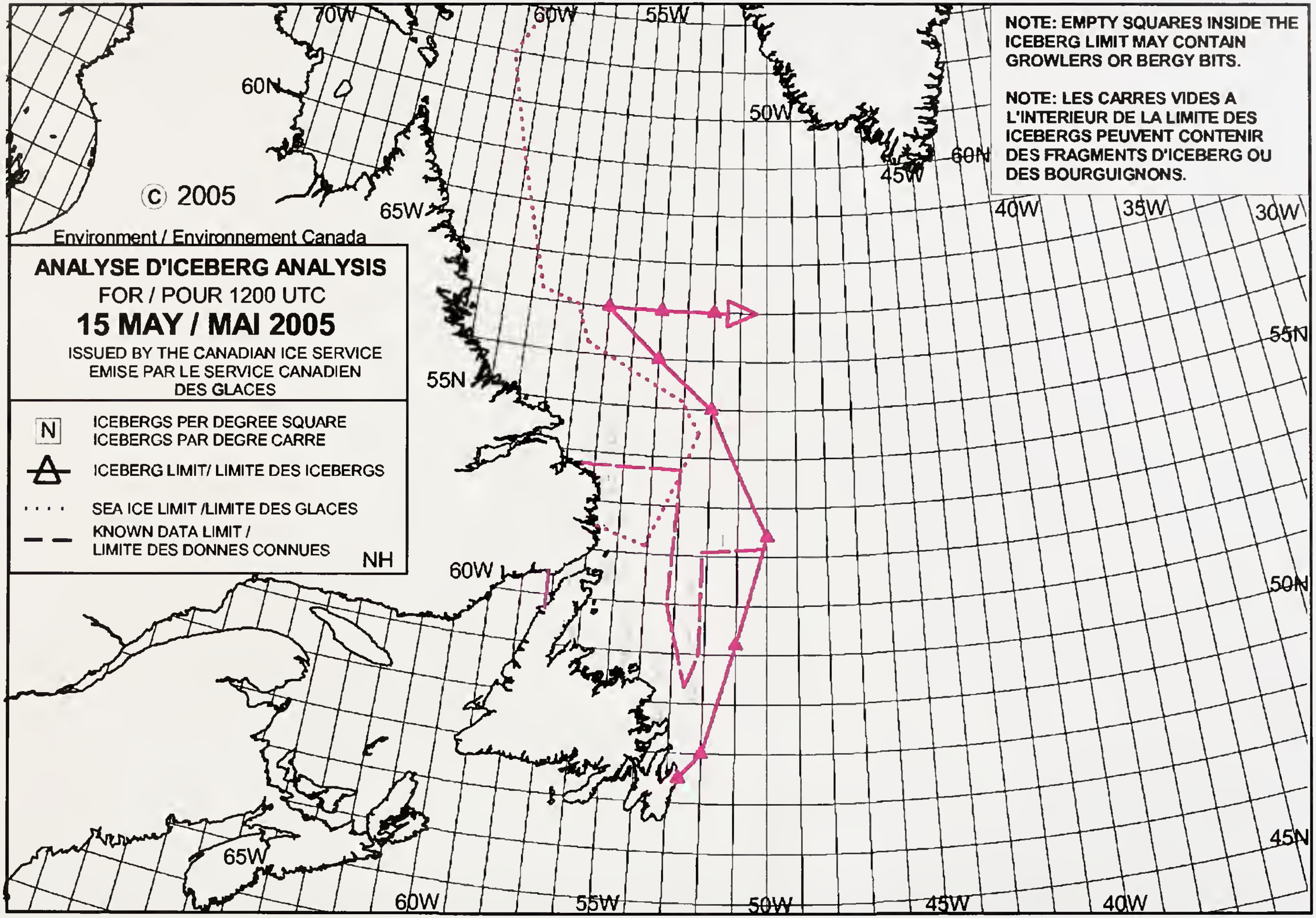
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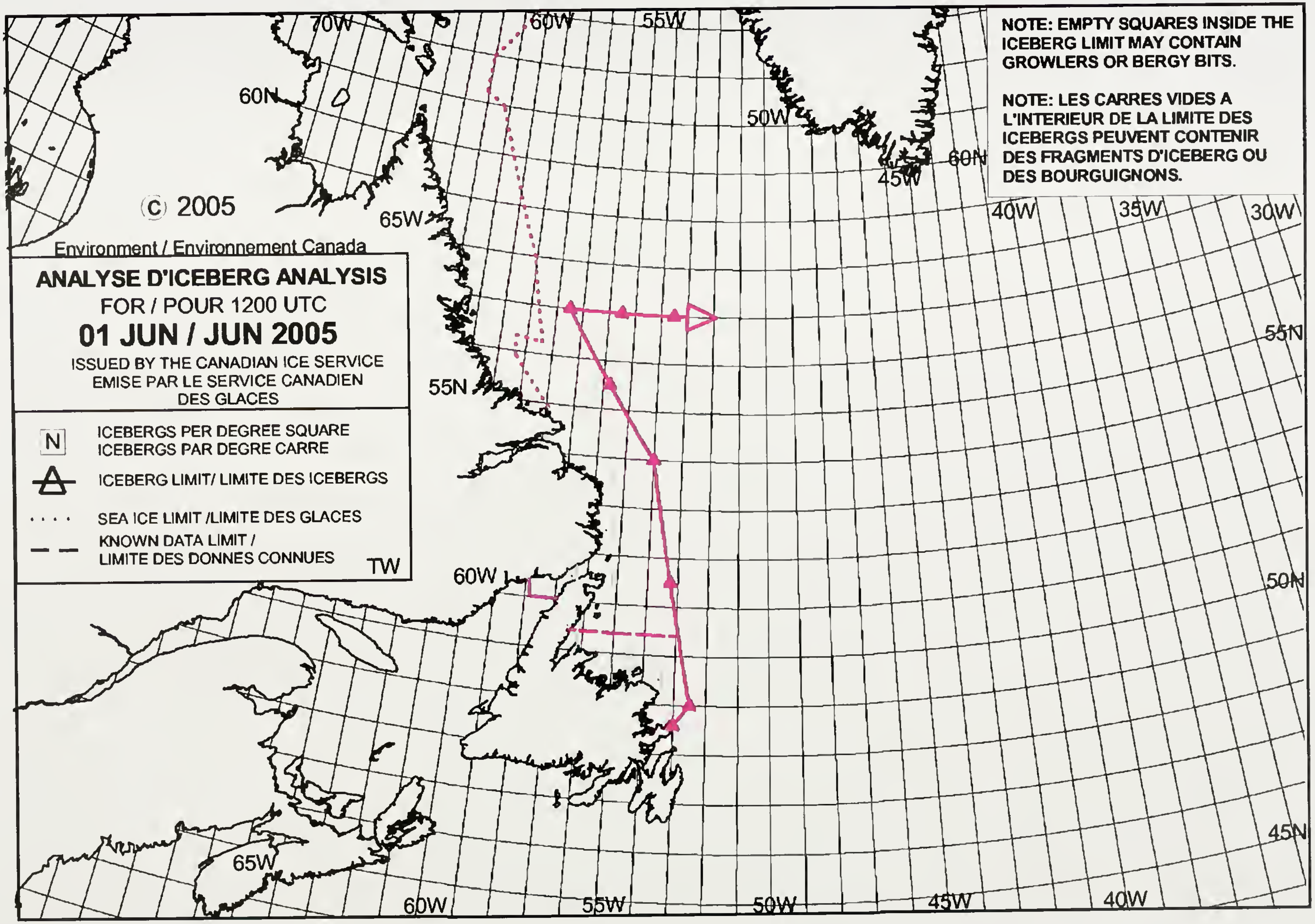
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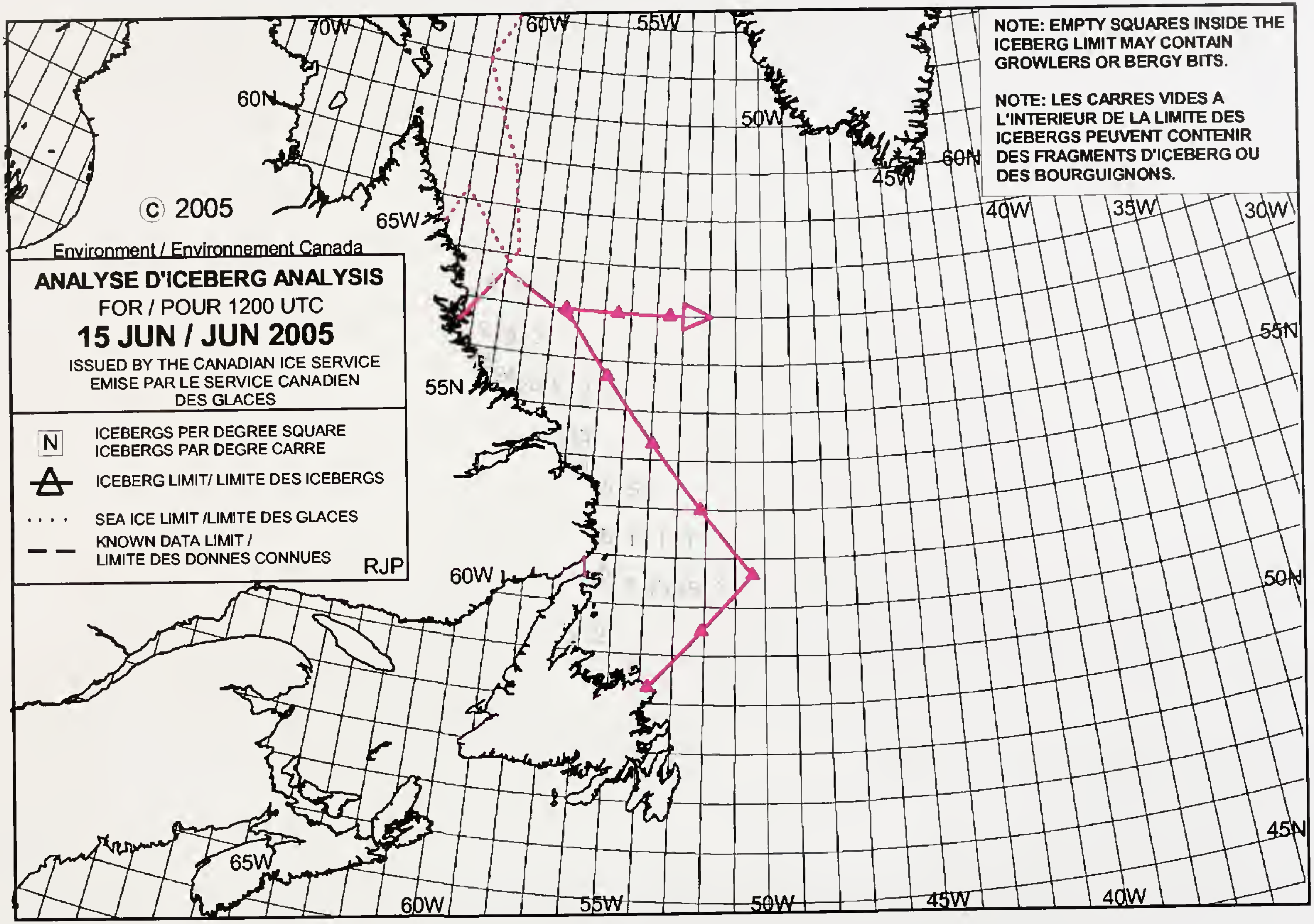
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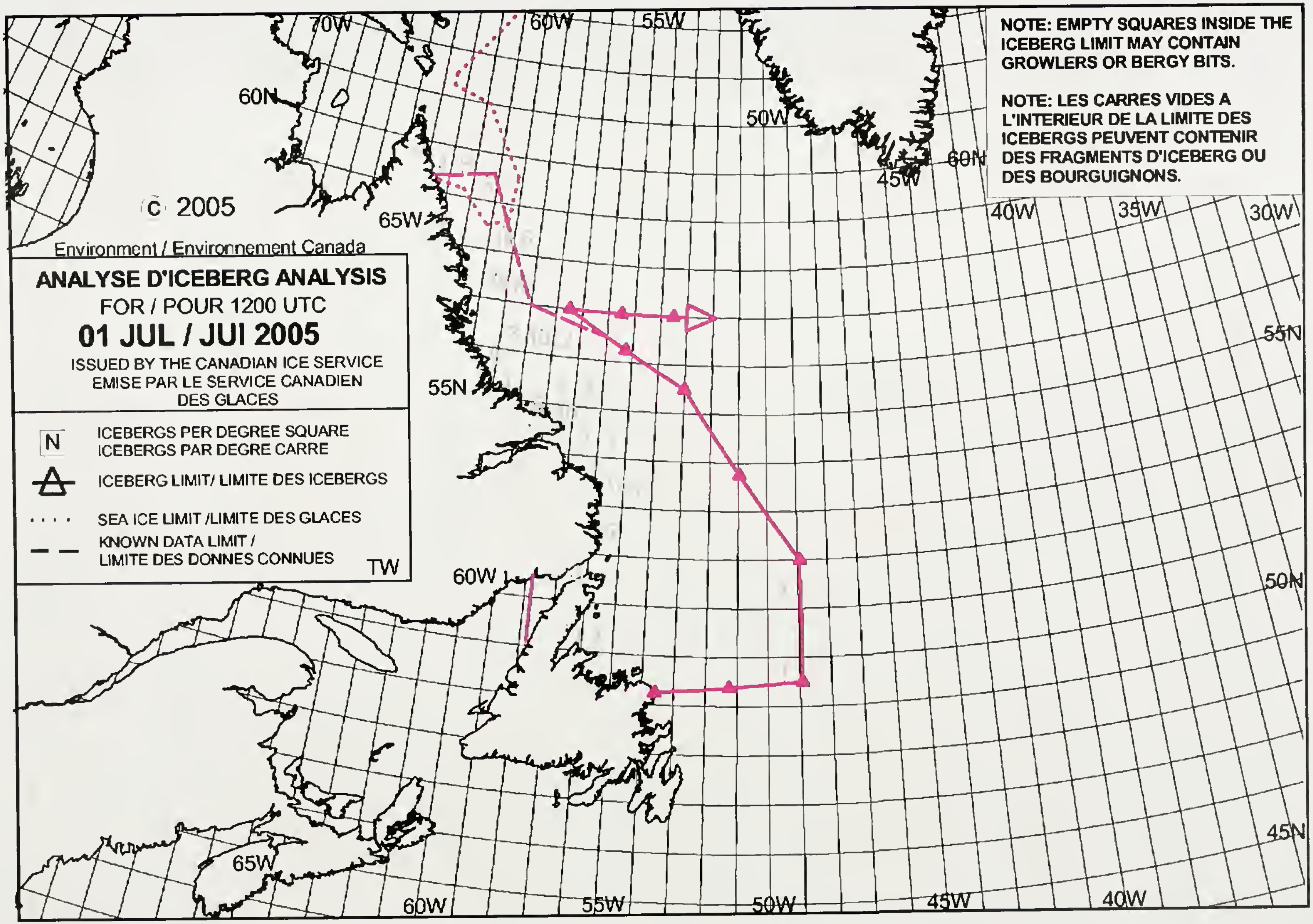
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National Ice Center
National Weather Service
Nav Canada Flight Services
Provincial Aerospace Limited
U. S. Coast Guard Air Station Elizabeth City
U. S. Coast Guard Atlantic Area Command Center
U. S. Coast Guard Atlantic Area Staff
U. S. Coast Guard Automated Merchant Vessel Emergency Response System
U. S. Coast Guard Communications Area Master Station Atlantic
U. S. Coast Guard Operations Systems Center
U. S. Coast Guard Research and Development Center
U. S. Naval Atlantic Meteorology and Oceanography Center
U. S. Naval Fleet Numerical Meteorology and Oceanography Center

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LT W. C. Woityra
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MST3 N. G. Myers
MST3 M. W. Jones

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Appendix A

Nations Currently Supporting International Ice Patrol

Appendix B

Reporting Sources

Reporting Source by Flag	Report
ANTIGUA & BARBUDA	
BAVARIA	2
BRUARFOSS	1
BAHAMAS	
AEGEN SPIRIT	27
AFRICAN SPIRIT	40
ATLANTIC CARTIER	30
AUSTRALIAN SPIRIT	6
IONIAN SPIRIT	12
JAEGER ARROW	1
JOH GORTHON	1
NORDIC HAWK	13
POLO M	12
RIP HUDNER	5
WESTWOOD ANETTE	1
BARBADOS	
KENT VOYAGEUR	1
BERMUDA	
CANMAR COURAGE	1
CANADA	
ANN HARVEY	2
ARCTIC	5
ATLANTIC AIRWAYS	2
ATLANTIC EAGLE	2
BURIN SEA	2
DES GROSEILLIERS	3
EDWARD CORNWALLIS	1
GEORGE R. PEARKES	2
HENRY LARSON	3
MATTEA*	92
OOCL BELGIUM	1

Reporting Source by Flag	Report
CANADA cont.	
PROVINCIAL AIRWAYS	18
TERRY FOX	3
TWILLINGATE LIGHTHOUSE	5
CYPRUS	
GLACIER POINT	1
FINLAND	
TERVI	4
GERMANY	
CANADA SENATOR	1
GIBRALTAR	
KENT NAVIGATOR	6
OSTKAP	1
TOFTON	13
GREECE	
CAP DIAMANT	1
OLYMPIC MENTOR	1
ORIENTAL	1
HONG KONG	
DARYA LOK	2
GOLDEN MERCHANT I	3
GOLDEN MERCHANT II	1
KWK EXEMPLAR	18
REDHEAD	2
YONG LER	1
ITALY	
SVART FALK	35
LIBERIA	
DZINTARI	7

Reporting Source by Flag	Report
LIBERIA cont.	
MAERSK PERTH	1
NEW YORK	6
SOUTHGATE	3
ZANIS GRIVA	1
ZIEMIA CIESZYNSKA	26
ZIEMIA GORNOSLASKA	1
LITHUANIA	
KAPITONAS STULPINAS	1
SVILAS	11
MALTA	
FREEDOM WAVES	4
VOYAGER	1
NETHERLANDS	
P&O NEDLLOYD AUCKLAND	1
SPAARNEGRACHT	1
NORWAY	
BERGE ARCTIC	49
BERGE NORD	72
MENOMINEE	13
OLIVIA	4
NORWEGIAN INT. REGISTER	
MALMNES	1
SPAR OPAL	2
PANAMA	
BUM YOUNG	1
CMA CGM HUDSON	2
CMA CGM TAGER	2

Reporting Source by Flag	Report
PANAMA cont.	
CONTINENTAL	1
ENCHANTER	3
ORIENT BRILLIANCE	7
PARADISE ACE	7
SINGAPORE	
EFFIE MAERSK	19
STAR HOYANGER	5
STAR ISOLDANA	8
SWEDEN	
FINNWOOD	3
MALAYSIA	
BUNGA ORKID EMPAT	1
TURKEY	
MEHMET AKSOY	6
UNITED KINGDOM	
BBC SINGAPORE	1
CANMAR VENTURE	1
CAPE OSPREY	1
QUEEN MARY 2	12
TMM CAMPECHE	1
UNITED STATES OF AMERICA	
GEYSIR	49
NATIONAL ICE CENTER	1
UNKNOWN ?	
ANGELINA THE GREAT	8
ANY SHIP	60

*Denotes vessel-participation award winner.

Appendix C

Implications of a Light Ice Season

CDR Michael R. Hicks

Abstract

In 1999 and again in 2005, very few icebergs crossed south of 48°N and into the transatlantic shipping lanes. Since these few icebergs were widely dispersed both spatially and in time, Ice Patrol determined that there was no significant threat to transatlantic shipping and, consequently, did not initiate daily ice-limit broadcasts. This action constituted a decision not to "open" the 2005 ice season. Appendix C examines the implications of this decision in terms of (1) the need to re-define Ice Patrol's concept and definition of the ice season, (2) the historical evolution of methods used to guard the Limit of All Known Ice (LAKI), and (3) improvements in Ice Patrol's processes resulting from the 1999 and 2005 ice seasons.

The Ice Patrol Season

The International Ice Patrol derives its mission—to monitor iceberg danger in the northwest Atlantic and provide the Limit of All Known Ice to the maritime community—from Regulation 6 of the *International Convention for the Safety of Life at Sea* (SOLAS) and U.S. Code, Title 46, Section 738. Specifically, in SOLAS the U.S. Government agrees to guard "the southeastern, southern and southwestern limits of the region of icebergs in the vicinity of the Grand Banks of Newfoundland for the purpose of informing passing ships of the extent of this dangerous region."[1] Furthermore, SOLAS requires that these limits be guarded "during the whole of the ice season, i.e., for the period from February 15th through July 1st of each year."[2] The SOLAS convention originally designated these dates in 1956 in an effort to determine the scale of U.S. Coast Guard support of the Ice Patrol for cost-reimbursement purposes.[3] In contrast to the SOLAS definition, Ice Patrol has defined its ice season as the period between the first and last date that a LAKI is established. During this period, IIP disseminates updated LAKI products daily. Historically, Ice Patrol has "opened" its season when ice created a hazard to transatlantic mariners and correspondingly has "closed" the season when the threat disappeared. Prior to the advent of aerial reconnaissance, opening (or, using early terminology, "inaugurating") the season meant deploying a continuous surface-vessel patrol for ice observation.

Aside from the fact that IIP's definition is inconsistent with SOLAS language, ice activity in both 1999 and 2005 underscored a flaw in IIP's conventional description for the ice season. In both years, Ice Patrol elected not to open its season—that is, Ice Patrol never established a LAKI or began disseminating daily products. This course of action may cause one to conclude that no ice season means that the risk of iceberg collision is diminished, while in fact, from Ice Patrol's perspective, the risk is the same: it is merely displaced northward. There is still a significant and growing amount of vessel traffic in an area historically prone to more intense iceberg activity. Ice

Patrol's efforts allow transatlantic mariners to safely use the most economical route through normally iceberg-infested waters. As such, Ice Patrol reconnaissance in a light season is just as critical as in a severe year since the decision not to establish a LAKI is equivalent to declaring the shipping lanes free of ice. Consequently, during both the 1999 and 2005 seasons, IIP continued to monitor iceberg danger and prevailing environmental conditions. In 2006, to emphasize the importance of IIP's reconnaissance and communication with transatlantic shipping—especially during a light year—IIP will adopt the SOLAS definition for ice season, which it designates as the period between 15 February and 1 July. However, the issuance of daily products will be determined in accordance with the direct iceberg threat to shipping lanes. Much like the concept of a hurricane season, there will always be an *ice season;* each one just varies in degree of severity.

The light seasons of 1999 and 2005, while unusual, were not unprecedented. The following section provides a historical context that discusses the evolution of Ice Patrol actions during other years with light iceberg activity.

Historical Context

The number of icebergs (or amount of sea ice) south of 48°N is a key indicator of season severity. This latitude is significant because it represents the location where the primary paths of offshore icebergs intersect the major transatlantic great-circle shipping routes **(Figure 1)**. The

Figure 1: Potential iceberg-danger area with great-circle shipping lanes overlaid in red (Note the approximate position of RMS *Titanic*'s sinking.)

number of icebergs crossing this parallel serves as a clue for IIP to establish a LAKI and initiate daily warnings.

Using this measure, Murphy (1999) presented a historical context for the extraordinarily light 1999 season by examining the 10 lightest seasons on record.[4] This report provides an excellent basis on which to examine the information available to and the decisions made by prior Ice Patrol Commanders faced with small iceberg populations. **Table 1**, adapted from Murphy (1999), includes the 2005 season. Because Ice Patrol began using aerial reconnaissance after World War II, it is useful to discuss progress in ice observation and LAKI dissemination by examining pre- and post-World War II seasons separately.

Rank	Year	Icebergs
1	1966	0
2 (Tie)	1940	1
2 (Tie)	1958	1
4	1941	3
5	1951	8
6 (Tie)	1924	11
6 (Tie)	2005	11
8	1931	14
9	1952	15
10	1999	22

Table 1. Years with the lowest number of icebergs estimated to have drifted south of 48°N

Pre-World War II: During pre-World War II seasons (1941 and earlier), considerable effort was required both to monitor ice conditions and disseminate iceberg information to passing steamships. The first light ice year of 1924 took the Coast Guard by surprise. Not knowing exactly how to approach a light season, Ice Patrol leadership took a business-as-usual approach. As such, U.S. Coast Guard cutters *Tampa*, *Modoc*, and *Ossipee* scouted for ice almost continuously despite the small number of icebergs (11 south of 48°N).

Reduced iceberg activity during this season allowed the IIP Commander (*Tampa*'s commanding officer) to make observations and informal investigations of the environmental causes of this light ice year. Early Ice Patrol records clearly show the tremendous emphasis placed on oceanographic study.[5] Knowledge of the iceberg environment remains essential to determining when to establish and disseminate the LAKI. In fact, rigorous study constitutes a key component of monitoring iceberg danger and is critical in effectively "guarding" the LAKI.

In addition to systematic study of the ocean by ship, Ice Patrol personnel sought the wisdom of native Newfoundlanders to learn about local indicators of expected ice-season severity. LCDR Edward "Iceberg" Smith said that the purpose of a port call at St. John's, Newfoundland, in May of 1924 was "to interview local mariners regarding ice conditions in the vicinity of Newfoundland."[6] After departing St. John's, the ice-patrol vessel continued northwest, interviewing observers at Belle Isle, Newfoundland, and Battle Harbor, Labrador. (See **Figure 2** for geographic references.) These observers attested to the unusually light extent of pack ice and noted the tremendous contrast between the 1924 early March seal hunt near the shores of White Bay, Newfoundland, and the 1923 hunt (approximately 350 nautical miles to the southeast).[7] Smith later commented in the 1940 annual report that results of the seal-fleet catch actually showed short-range iceberg-forecasting promise since news from the seal fleet preceded realization of a light iceberg year by about one month.[8]

During the 1931 season, when only 14 icebergs drifted into the shipping lanes, cutters *Pontchartrain* and *Mojave* remained on call for ice-patrol duty, while the oceanographic vessel *General Greene* conducted extensive oceanographic sampling. In addition to these scientific duties, *General Greene* performed double duty by acting as a sentinel to warn shipping of impending iceberg threats and to transmit ice broadcasts as scheduled. The 1931 annual report also includes results from an expedition that sent "Iceberg" Smith to the *Graf Zeppelin* for an ice

Figure 2. Map of Newfoundland and Labrador

and oceanographic observational flight into the Kara and Barents Seas. While study of the ocean remained a critical component of monitoring iceberg danger, IIP learned from the light 1924 season and decided not to call cutters *Pontchartrain* and *Mojave* to ice-observation duty.[9]

In 1940 and 1941, Ice Patrol followed procedures similar to those of the 1931 season. In each of these seasons, IIP elected not to inaugurate a continuous surface-vessel patrol. In each of these years, though, study of the ocean remained a high priority. In 1940, the *General Greene* continued its oceanographic cruises. In addition, *Northland* made a cruise into Baffin Bay along the west coast of Greenland to gain a better understanding of the source of icebergs. The annual reports of 1931, 1940, and 1941 are not clear about any broadcast schedule maintained by these scientific cruises, but it is evident that their presence on the Grand Banks provided a safety factor for Ice Patrol. Still, the decision not to inaugurate a continuous surface-vessel patrol is analogous to the present-day decision not to open the season since it is based on ice conditions revealed through intense study of the ocean environment.

Of particular interest is IIP's 1940 annual report, which records hundreds of ice observations from 10 different detachments of the Newfoundland Rangers.[10] During their short 15-year tenure (1935-1950), the Rangers were stationed in remote outposts of Newfoundland and Labrador in places like Twillingate, Battle Harbor, and St. Anthony. The British Government commissioned the Newfoundland Rangers in 1935 to serve as government representatives to these outlying communities. This organization disbanded in 1950 shortly after Newfoundland joined Canada. Of the 204 Newfoundland Rangers, 55 were accepted into the Royal Canadian Mounted Police and continued to serve Canada.[11] Although their information appeared only in IIP's 1940 annual report, the Rangers are an excellent example of Ice Patrol's dependence on voluntary ice observations and the spirit of international cooperation that is still alive today.

Post-World War II: In the years following World War II, ever-advancing ice- and oceanographic-observation techniques provided the Ice Patrol Commander with the tools

necessary to more effectively and efficiently allocate resources needed to monitor iceberg danger. The most meaningful technological leap was the use of aircraft to provide a much better overview of ice conditions. In 1951, Ice Patrol relied on aircraft exclusively, using two PB1G Flying Fortresses based out of Argentia, Newfoundland. Similar to today's strategy, aerial reconnaissance that year used parallel search patterns over the most critical ice-danger areas, using RADAR with LORAN for navigation.[12] The seasons of 1952, 1958, and 1966 followed a similar approach, using aircraft (HC-130B in 1966) exclusively for reconnaissance and keeping surface ships on call in the event that ice conditions warranted a continuous patrol. In each of the light seasons of the 1950s and 1960s, IIP did not order a continuous surface-vessel patrol, though cutters remained on 72-hour standby for patrol. In each year, IIP did establish the LAKI and continued to broadcast twice-daily ice warnings in accordance with patrol orders.[13] Again, "opening" the season loosely translated into commencing a continuous surface-vessel patrol. Here, the use of aircraft supplied an invaluable monitoring resource and rendered the patrol vessel relatively less significant than the iceberg-scouting ships of the 1920s, 1930s, and 1940s.

In all but the 1924 season, the Coast Guard did not dispatch a dedicated ice-observation cutter, but did assign surface vessels to conduct oceanographic cruises to monitor and study oceanographic conditions. Dedicating this costly resource to understanding icebergs' environment highlights the importance of the service provided by ships like *Evergreen* and *General Greene*. The need for intense scientific cruises has largely been supplanted by an improved ability to monitor ice and ocean conditions remotely via satellite and made available via the Internet.

Ice Patrol Process Improvements

In 1999, IIP did not officially open the ice season—that is, did not establish and disseminate daily LAKI products. However, IIP expended 272 C-130 hours on patrols to monitor iceberg danger during this year. Though Ice Patrol tracked thousands of icebergs in its database, only 22 drifted south of 48°N. At no time did these icebergs pose a significant threat to transatlantic shipping.

Three important factors distinguished 1999 from previous light ice years: (1) the existence of the Canadian Ice Service's (CIS) iceberg product, (2) unprecedented access to remotely sensed data via the Internet, and (3) the presence of the Hibernia oil platform on the Grand Banks. These factors offered the Ice Patrol Commander a significant advantage over his predecessors. Through the Internet, it was possible to view weather analyses and forecasts, sea-surface temperatures derived from infrared sensors on satellites, sea-ice extent and concentration inferred from space-borne synthetic-aperture RADAR, and satellite-based wind and wave information all on a 17-inch computer monitor in the comfort of a 68°F office. Remotely sensed data not only offered convenience but also painted a much more complete and timely view of the ocean's complexities. In addition, as of 1997, a near continuous stream of vessel traffic between St. John's and the Hibernia oil platform—some 170 nautical miles to the east-southeast—added another line of defense for sighting approaching icebergs. Companies producing oil on the Grand Banks supplied a new multibillion-dollar incentive to monitor iceberg danger. Ice Patrol continues to reap tremendous benefits from the steadily increasing activity on the Grand Banks. Expanding exploration and production activities will only increase the amount of iceberg-observation data available to IIP. Finally, the 1999 Commander received queries from a concerned maritime community as to the whereabouts of IIP's traditional LAKI products. These questions were easily addressed by quick reference to the CIS iceberg-limit product on that

organization's website, but they underscored the need to assure mariners that Ice Patrol was still on the job.

The year 2005 tied 1924 as the sixth-lightest year on record. Lessons learned from 1999 provided the basis for improving processes for the 2005 season. Throughout the entire season, IIP processed a mere 125 icebergs through the Berg Analysis and Prediction System (BAPS); the average for 2002 to 2004 was 2,486 targets. Still, Ice Patrol leadership ultimately decided not to open the ice season after carefully considering the following factors:

(1) The iceberg population south of 48°N,
(2) CIS was providing daily ice information,
(3) The need to keep mariners informed,
(4) Personnel readiness—that is, the need to train both reconnaissance and Operations Center watch personnel.

Ice Patrol reconnaissance flights had revealed that there was no iceberg threat to transatlantic shipping, and mariners approaching the Grand Banks and Canadian waters still had a source for iceberg information through the CIS daily iceberg product. Moreover, applying a lesson learned from the 1999 season, IIP began disseminating a weekly message in accordance with the published "Announcement of Services." These messages assured the maritime community that Ice Patrol was actively monitoring iceberg danger and that a ship traveling along the most economical great-circle transatlantic shipping route between Europe and North America would not encounter ice.

Personnel readiness posed another concern altogether. By late May—well after a normal ice season usually begins—several new IIP members had not yet seen an iceberg, let alone produced and disseminated a daily LAKI product. Creative and dedicated staff devised an innovative solution to ensure that personnel and equipment were ready to assimilate iceberg reports, run the drift and deterioration models, and send out accurate, timely LAKI products. This inspired the creation of a "mock" ice season for training. This simulated ice season employed all personnel during a three-week period in September 2005, long after any potential iceberg threat had subsided. During the first week of the mock season, all personnel had the opportunity to create and actually transmit test products via NAVTEX and HF-radio graphical fax charts. To avoid confusion in the maritime community, IIP made it clear that these products were only for training. The second and third weeks of the season tested and trained watch standers on every aspect of Operations Center functions, including iceberg merging and deleting, drawing the LAKI, and processing icebergs reported outside the LAKI. This successful training evolution resulted in the qualification of six watch personnel and advanced the knowledge of all who participated. This tool will be employed during future post- and preseasons to ensure that the workforce maintains peak readiness for each season.

A Crucial Decision

Establishing the LAKI and commencing daily warnings is one of the most critical choices made by the Ice Patrol Commander. If a season is opened too early, there is the potential that IIP's credibility and mariners' confidence in its products will suffer; too late and there is a risk that critical safety information will not reach the mariner on time. The Commander must consider many factors to make this call, including sea-surface temperatures, the state of the Labrador Current, location of the iceberg population, sea-ice extent and concentration, and reports from

shipping. While all of these factors are considered, the ultimate decision is based on his or her comfort with the potential level of risk to the transatlantic mariner.

One dramatic case where the Ice Patrol Commander's discomfort resulted in a remarkably timely season opening occurred in February 1993. **Figure 3** shows the iceberg distribution on the evening of 1 February. Around this date, the container ship *OOCL Challenge* set sail from Montreal bound for the UK. The season had not yet opened. On 2 February, after assessing the number of icebergs south of 48°N, the Ice Patrol Commander elected to open the season by establishing the LAKI and commencing daily ice warnings, based largely on the iceberg population in the shipping lanes.[14] Meanwhile, the M/V *OOCL Challenge* proceeded out of the Gulf of St. Lawrence toward the Grand Banks. On 4 February, two days after the Ice Patrol season had opened, M/V *OOCL Challenge* struck a growler inside IIP's published LAKI while steaming at 18.5 knots. The collision caused "considerable damage, a 30' gash in the bow and additional cracking in the ballast tanks."[15]

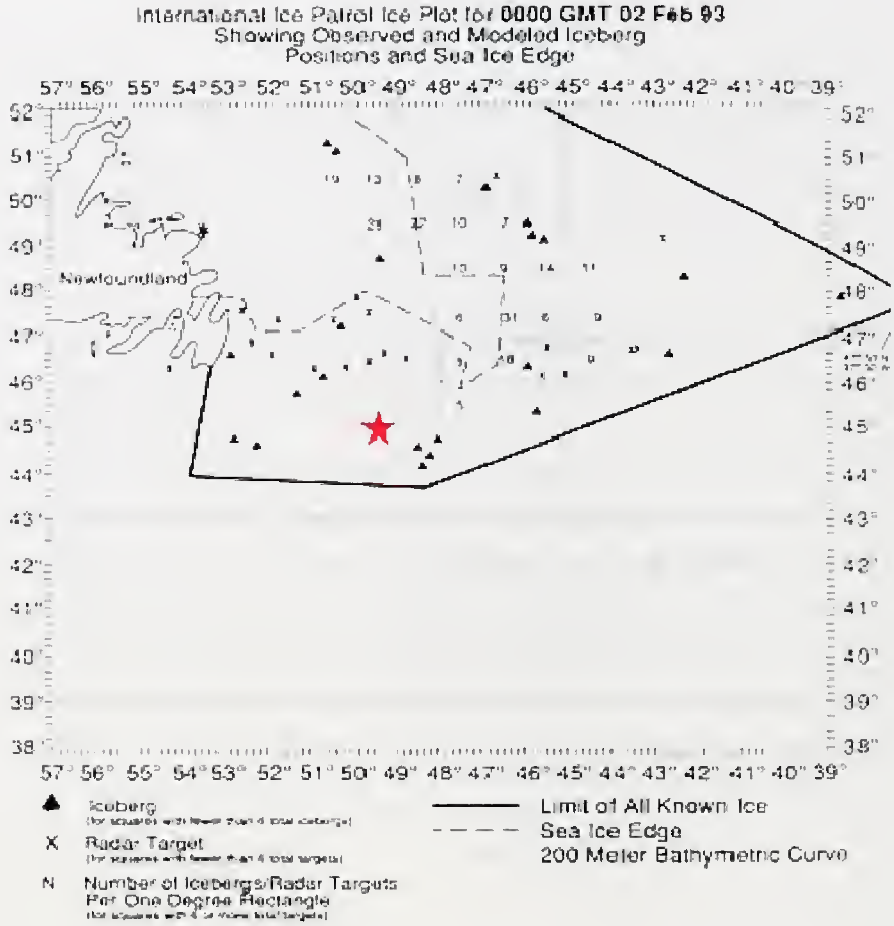

Figure 3. Iceberg distribution on 1 February 1993 (Red star represents approximate position of M/V *OOCL Challenge*'s collision.)

It is not clear whether this vessel received IIP's warnings on the 2nd and 3rd of February or whether the ship's master would have changed course to remain outside the published LAKI. But in this case, the Ice Patrol Commander's discomfort and subsequent actions gave the M/V *OOCL Challenge* ample opportunity to steer clear of iceberg danger and avoid costly damage. In 1993, two other vessels collided with icebergs inside Ice Patrol's published LAKI. Having the capability to look back at 1993 is invaluable in shaping future Ice Patrol leaders' understanding of the risk that ice conditions pose to the transatlantic mariner.

Summary and Lessons Learned

In summary, the light ice years of 1999 and 2005 highlighted opportunities for Ice Patrol to improve its processes—not only for future mild ice years but for incorporation into standard operating procedures. First, both the 1999 and 2005 ice seasons demonstrated the logic in modifying the Ice Patrol definition of ice season to conform with the SOLAS definition. As of 2006, the Ice Patrol season will be fixed in time from 15 February to 1 July every year. During this period, Ice Patrol will continue to monitor iceberg danger and will be prepared to establish the Limits of All Known Ice and disseminate products in accordance with the "Announcement of Services."

The key component in "monitoring iceberg danger" is making systematic ice and environmental observations; the requirement for a careful assessment of the risk of iceberg collision to the transatlantic mariner has remained unchanged since 1912. Today, improved access to Internet products and increased commercial activity on the Grand Banks augment C-130 aerial reconnaissance and have replaced the costly labor-intensive ship-based oceanographic cruises that used to "guard" the ice limits in the past. Now, with a few clicks of a mouse, the Ice Patrol Commander can instantly get a comprehensive view of the atmosphere and ocean environment to help plan reconnaissance and make strategic and tactical decisions on Ice Patrol operations. This wealth of environmental data, coupled with a tremendous increase in oil exploration and production activity, has provided the Ice Patrol Commander with more information than ever before. With an expected increase in container, bulk-ore, and tanker-vessel traffic, these extra eyes will serve as both a welcome resource to help guard the Limits of All Known Ice and the impetus for continued careful observation and interpretation of the iceberg threat to shipping.

As a result of both the 1999 and 2005 seasons, IIP incorporated changes into its standard operating procedures. Because of inquiries from shipping during the 1999 season, Ice Patrol now broadcasts a weekly product beginning on the first Friday of each season to assure mariners that IIP is monitoring ice danger, allowing transatlantic vessels to follow the safest, most economical route across the Atlantic. Furthermore, in an effort to train and qualify new Operations Center personnel, IIP staff innovatively devised a mock season to simulate active ice conditions. This valuable tool has served to qualify watch officers and is available to future Ice Patrol Commanders to help prepare for each upcoming season.

The M/V *OOCL Challenge*'s collision in 1993 poignantly illustrates the importance of IIP's decision to commence disseminating daily LAKI products even when relatively few icebergs threaten the transatlantic shipping lanes. Mariners rely on and have come to expect vigilant ice observation. The recent light ice seasons of 1999 and 2005 have stressed the need to assure mariners that IIP vigilantly monitors ice conditions regardless of a season's severity. These light seasons challenge the way Ice Patrol operates and inspire continuous improvement in an effort to achieve IIP's vision: to eliminate the risk of iceberg collision.

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[1] International Maritime Organization. (2004). *Consolidated text of the International Convention for the Safety of Life at Sea, 1974, and its Protocol of 1988: articles, annexes and certificates*, Chapter V, Regulation 6, 359.
[2] Ibid.
[3] U. S. Department of State Multilateral Agreement. (1956). *Safety of Life at Sea: Financial Support of the North Atlantic Ice Patrol*, Exhibit A-1, 1.

[4] Murphy, D. L. (1999). An Historical Perspective to the Mild 1999 Ice Year. *Report of the International Ice Patrol in the North Atlantic,* Bulletin No. 85, 57-62.
[5] Wheeler, W. J. (1924). Reports of Commanding Officers. *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 15, 36-38.
[6] Smith, E. H. (1924). Oceanographer's Report. *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 15, 75.
[7] Ibid, 75-78.
[8] Smith, E. H. (1940). Ice Observation in the Greenland Sector, 1940. *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 30, 25.
[9] International Ice Patrol. (1931). *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 21, 1.
[10] International Ice Patrol. (1940). *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 30, 6-10.
[11] Newfoundland Rangers Home Page. (2004). http://home.ca.inter.net/~elinorr/ranger-main.html.
[12] Branson, P. S., Dinsmore, R. P., Pisiccho, S., Soule, F. M. (1951). *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 37, 2.
[13] Ibid., 1.
Branson, P. S., Soule F. M. (1952). *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 38, 1-2.
Dinsmore, R. P., Morse, R. M., Soule, F. M. (1958). *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 44, 2.
Murray, J. E. (1966). *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean,* Bulletin No. 52, 2.
[14] Murphy, D. L. (March, 2006). Personal communication.
[15] Hill, B. T. (2001). *Database of Ship Collisions with Icebergs.* http://www.icedata.ca/icedb/ice/scdb_index.html.

Appendix D

APN-241 Radar-Detection Experiment

LT Scott A. Stoermer

Synopsis

During IRD 4, IIP conducted an experiment to determine the ability of the HC-130J's APN-241 radar system to detect and identify icebergs on or near the Grand Banks of Newfoundland. The experiment occurred on 29 March 2005 onboard CG2006 between 1325 and 1750 UTC.

General Features of the APN-241

- The APN-241 is a low-power (11-150 watt) multi-mode surface-search and weather radar located in the nose (radome) of the HC-130J aircraft. The radar is controlled by a panel and trigger-style control interface on the flight deck located between the pilots.
- The APN-241 modes are weather (WX), surface search (MAP), and ground mapping (MGM). The radar operates in 1.5, 3, 5, 10, 20, 40, 80, 160 and 320 nm range scales, but each mode does not permit the use of all range settings. Additionally, the radar has dynamic range/antenna tilt functionality.
- The radar sweeps 270° (±135°) from the nose in alternating sweep directions. The system is sector adjustable (±15°, 30°, 60°), and the display is zoom capable (**Figure 1**). Essentially, the radar will shift the sweep to a particular sector (as identified by the location of the display cursor) and allow the user to select the sector width. The zoom feature then allows the user to zoom in on the display cursor's position.
- All four of the liquid-crystal display panels on the flight-deck main console can show the radar display. **Figure 2** shows radar return on display 2 and the digital map on display 3. Additionally, the system allows shared sweeps, which means that one display can show the entire (270°) sweep, while another one zooms on a sector.
- The radar system is integrally linked with the other systems on the aircraft, including the digital map, autopilot, navigation system and Heads Up Display (HUD). In fact, the position of the cursor on

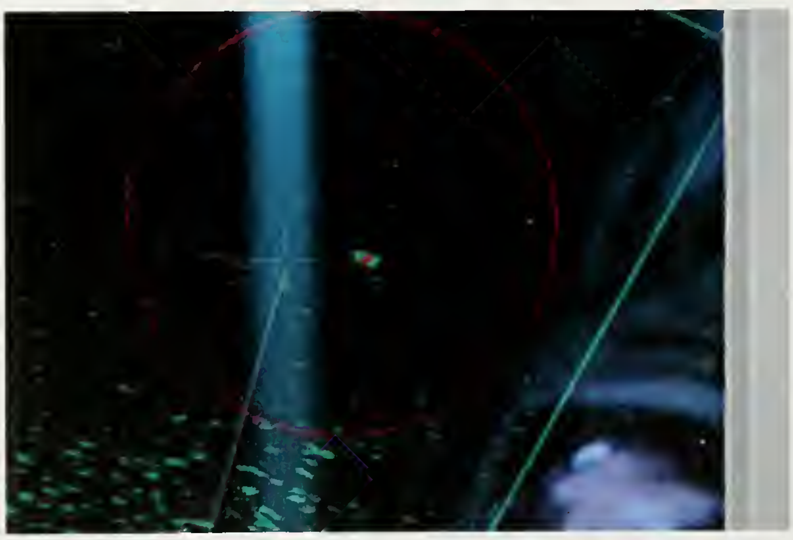

Figure 1. Sector-zoom of target (iceberg). Target color (green to red) is an indication of return strength.

the radar display is visible through the HUD and marks a target's actual position on earth. For example, when a radar operator places the cursor on a target, the cursor on the HUD functions somewhat as a cross hair, directing the pilot's vision to the target's position.

Figure 2. Display 2 (left) and 3 (right) on the flight deck of CG2006. Note the radar depiction on display 2 and the digital map on display 3. While difficult to see in the image above, the cursor ("+") on the radar and map are connected, so that cursor movement on the radar screen translates into movement on the map.

Experiment Design and Results

The experiment consisted of three phases: (1) initial detection, (2) north-south expanding parallel search, (3) east-west expanding parallel search. Each phase is described below. To minimize the number of variables involved, patrol criteria were kept as similar to normal Ice Patrol HC-130H operations as possible, that is, 250 knots indicated air speed at 7,000 feet.

GENERAL

Based on an iceberg's forecasted position, which had been detected and identified two days earlier, a box flight plan (5,500 to 8,000 feet) was filed for the experiment (**Figure 3**). Crew positions included a Radar Ice Observer (RIO) on the flight deck and an Ice Observer at each of the paratroop-door windows. The RIO was provided limited training on the use of the APN-241 and was able to operate the system on a very limited basis. For most of the patrol, in fact, the pilots operated the radar. **Figure 4** displays the flight track, and **Table 1** summarizes the detection results of Phases 2 and 3. Based on the pilots' recommendation, the radar was set in MGM mode for the duration of the patrol. Antenna gain and antenna tilt were adjusted during the patrol to maximize radar performance.

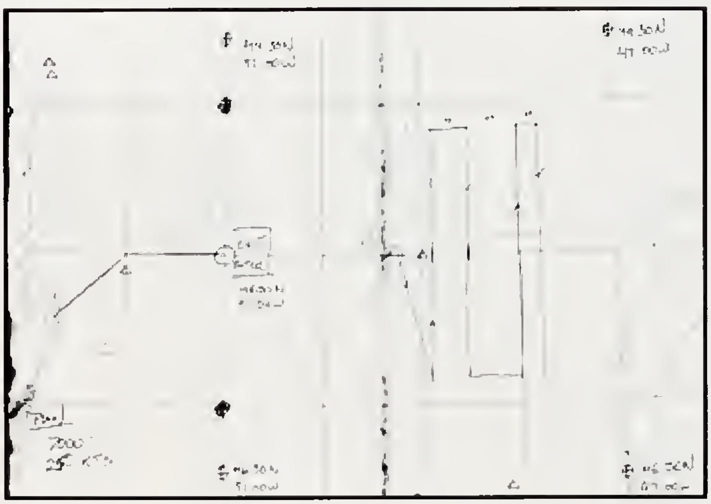

Figure 3. Flight planning used for the experiment. The corner positions indicate the limits of the boxed flight plan filed with the Flight Service Center and Air Traffic Center.

PHASE 1: INITIAL DETECTION

From the box entry point, the radar was used to search for a target in its anticipated position. Target density noted during the transit was minimal, with fewer than 12 boats detected and visually identified. There were no boats within 30 nm of the iceberg target. The suspected iceberg target was detected at 50.9 nm with the 80 nm range setting. The radar display was zoomed to the position and the target was further analyzed. Positive target identification did not occur until it was seen from the flight deck at 25 nm. Once detected and identified, the aircraft descended to estimate the on-scene environmental conditions and fully document the physical characteristics of the iceberg. Additionally, the time and position of the iceberg were marked. Once back at patrol altitude, Phase 2 commenced. Note that all subsequent iceberg searches are for a known target and position.

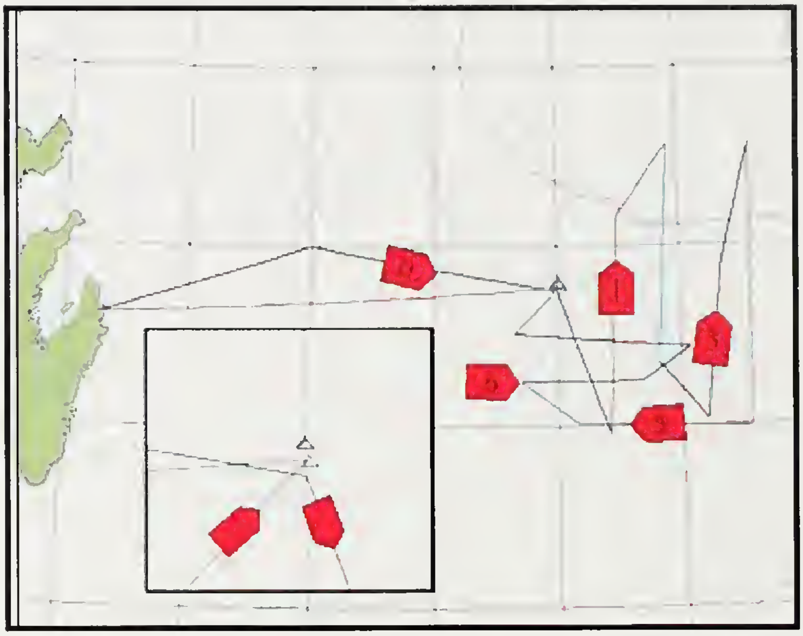

Figure 4. Results of the patrol. Leg numbers are indicated above (2,4, and 7 were left off the plot for ease of viewing). The inset shows the change in iceberg position throughout the experiment. For perspective, the distance between iceberg positions is approximately one nautical mile.

Figure 5. Photograph of the iceberg detected during this experiment. Note the dry-dock shape and the wake caused by the wash/back-wash of the swell.

Environmental Conditions

- Wind: light (12 kn) from the east (100°T)
- Sea State: calm (1 m swell) with no discernable wind waves
- Visibility: unrestricted at the surface and from patrol altitude to surface

Iceberg Description

- Shape: dry dock (**Figure 5**). The iceberg was typical of dry-dock icebergs with two side walls separated by a split that extends below the water surface. Neither

side wall was remarkable (dramatically shear or rounded). The wash/back-wash of the swell impacting the iceberg was visible as a wake.

- Size: small. IIP categorizes small icebergs as those with lengths between 15 and 60 m.
- Waterline length: ~30 m (as estimated by the Ice Observer, using binocular reticle and IIP size-estimation chart). Subsequent ship observations of the iceberg reported lengths ranging from 30 to 70 m, which puts the iceberg in the upper range of the small category.
- Height: ~10 m (estimated)

PHASE 2: NORTH-SOUTH EXPANDING PARALLEL SEARCH

Once at patrol altitude, four north-south legs were flown at increasing offset from the known iceberg target. The first leg was flown at 15 nm offset, the second at 30 nm, the third at 50 nm, and the fourth at 60 nm. Leg length was planned for ~100 nm to allow observation of detection, target return (both on zoomed and whole display), and loss of the target from the radar screen. Once the target was lost, the aircraft proceeded to the waypoint at the start of the next leg. The target was confidently (no false-alarm targets in background) detected at the 15 and 30 nm offsets. The iceberg was detected at 50 nm, but not without zooming on the known position of the target. The target was not detected at 60 nm. The radar range was set at 40 nm for the first two legs and 80 nm for the second. **Table 1** summarizes the detection results.

PHASE 3: EAST-WEST EXPANDING PARELLEL SEARCH

After Phase 2, the leg orientation shifted to east-west for Phase 3. The datum offset for Phase 3 was similar to Phase 2, with the exception that the 60 nm offset leg was eliminated. The iceberg was confidently detected during the 30 nm and 15 nm offset legs, but not on the 50 nm offset leg. The radar range was set to 80 nm during the 50 nm offset leg and 40 nm for the last two offset legs. **Table 1** summarizes the detection results. At the completion of Phase 3, the aircraft returned to the iceberg to mark its final position and time. **Table 2** summarizes the target's position and drift throughout the experiment.

Summary

- Initial-detection (Phase I) range was excellent, but when evaluating this conclusion, one should also consider the ideal on-scene search conditions, which included good visibility, low sea state, and negligible target density. These ideal conditions are unusual on the Grand Banks.
- Phase 2 and Phase 3 detection results are also promising, but must be weighed with the ideal search conditions and the fact that operators were "alerted," that is, the target and its position were know prior to detection. No matter how qualified the experiment's positive results are, however, the high-detection rate (five of five successful detections for ranges similar to normal IIP operations) warrants further investigation.
- The APN-241 can mark and log targets with user-customized identifiers. Marked targets indicate geographic positions vice actual target position. For example, a target will "drift" from its mark because the radar does not "track" targets, making subsequent target detection more difficult. In other words, targets observed later in a patrol may have been detected or identified earlier, but an operator may be unable to distinguish immediately between old and new targets.
- Currently, there is no way to take digital radar data from the aircraft. Ideally, IIP personnel could leave the aircraft with a digital target list or a digital archive of the radar return and

Leg Number	Offset From Datum (nm)	Direction of Travel	Initial Detection Range (nm)	Detection Confidence	Radar Range (nm)
0	Unknown	Toward Target	50.9	High	80
1	15	North	31	High	40
2	30	South	40	High	40
3	50	North	55	Low	80
4	60	South	N/A	N/A	80
5	50	West	60	Low	80
6	30	East	42	High	40
7	15	West	35	High	40

Table 1. Summary of detection data. **Figure 6** defines Initial Detection Range. Detection Confidence is a qualitative assessment of the ability of the operator to detect a target within the background clutter and determine whether it is of interest or just surface clutter.

replay it on a computer. Lockheed Martin is investigating the ability to upload Custom Data Waypoints, but the ability to upload radar-return data does not exist.

- Though the radar's shared-sweep capability may optimize surface searching, it could potentially cause interference between surface searches for icebergs and pilots' weather-avoidance needs because the antenna-tilt settings of the weather and surface-search modes are very different. Further investigation is necessary to understand the true impacts.
- Trivers and Murphy (1993) document a fairly extensive test of the capabilities of the APS-137. Regarding target-identification ability, the APS-137 is far superior to the APN-241 because of its searchlight mode (ISAR operation). The APN-241's target-identification tools are limited and unreliable for target identification. Its target-identification tools include gross-target movement, target shape/return when zoomed, and radar interference/attenuation.
- As mentioned above, the results documented here are promising and surely point to the need for additional tests and ground-truth experiments. Further experiments should focus on a more realistic target field (ships and icebergs) and more realistic environmental conditions. Additionally, sector searches, as well as more parallel searches, should be used to maximize detection opportunities and detection of targets from various aspect angles.
- Based on the above findings, the APN-241 is not by itself an adequate sensor for IIP operations. While its ability to detect targets shows some promise, the system lacks a solid target-identification tool or mode.

Time	Position	Distance/Direction (nm / °T)	Speed (kn)
1430Z	47°46.8N / 49° 00.3W	----------	----------
1648Z	47°45.7N / 48° 59.9W	1.13 / 189	.49

Table 2. Summary of position and drift data

Non-Radar Observations

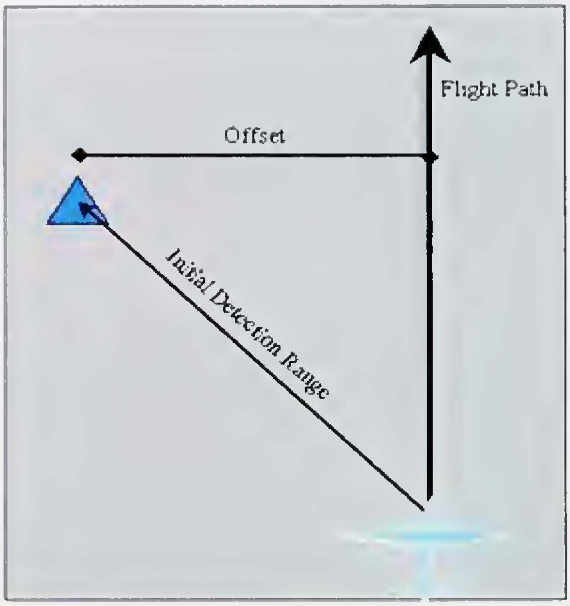

Figure 6. Graphical definition of Initial detection range

- The current configuration of the HC-130J would not support IIP operations given that the only control of the radar is at the hands of the pilots. An Ice Patrol ready HC-130J would include workstations at the rear of the flight deck or a palletized sensor system in the cargo compartment. Full control of the sensors—without interfering with routine flight-deck operations (navigation, radio communications, etc.)—from the flight-deck workstations or palletized sensor package would be necessary for IIP reconnaissance. While flight-deck workstations and a palletized package within the cargo compartment are design solutions, they reflect the operational requirement for independent control of the sensor(s). This independent control is critical to the existing ice-reconnaissance operational structure. While other solutions are possible, they must be measured against the proven success of the FLAR-SLAR-visual ice observer system currently employed on the HC-130H.
- Ice Patrol operations would require larger displays than those currently on the flight deck of the HC-130J (**Figure 2**).
- The existing windows in the paratroop doors are not acceptable for IIP operational use; however, the integral stools are an interesting solution to seating at future scanner windows. Large scanner windows would be required for IIP reconnaissance. Bubble windows would be ideal because they would provide ice observers with a dramatically wider field of vision than flat windows.
- The Heads Up Display available to both pilots suggests a possibility for the future of visual ice observation. Hypothetically, a Heads Up Display in the ice observers' windows would afford them the benefit of the radar operator's cursor placement and therefore help them focus their visual scanning. Obviously, this solution would benefit nearly all missions, not just Ice Patrol's.
- The Internal Communications System on the HC-130J is much improved over the HC-130H system. The lack of ambient system noise and voice-operated (VOX) selectivity provided clearer communication with less effort.

Acknowledgments

The International Ice Patrol extends appreciation to the crew of IRD 4 (LCDR Byron Willeford, YN1 Tim DeVall, MST2 Allie Rodgers, and MST3 Jeromy Sherrill). Ice Patrol also thanks the crew of CG2006 (LCDR Dan Walsh, LT Roy Eidem, AETCS Lester Ward, AET1 Robert Sunderland, and AMT3 Shane Absher) for their professionalism during the experiment. The

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References

Trivers, G. A., & Murphy, D. L. (1993). *Forward-Looking Airborne Radar Evaluation.* International Ice Patrol Technical Report 95-01.

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1954	AD780 851/2
1955	AD780 852/0
1956	AD780 853/8
1957	Unavailable
1958	AD780 854/6
1959	AD780 855/3
1960	AD777 945/7
1961	AD777 950/7
1962	AD777 951/5
1963	AD777 952/3
1964	AD774 510/2
1965	AD774 511/0
1966	AD692 936
1967	AD774 504/5
1968	AD774 505/2
1969	AD718 504
1970	AD736 981

Year	NTIS Accession #
1971	AD778 013/3
1972	AD780 537/7
1973	ADA020 336/4
1974	ADA055 267/9
1975	ADA058 898/8
1976	ADA066 081/1
1977	ADA075 246/9
1978	ADA079 474/3
1979	ADA093 073/5
1980	ADA113 555/7
1981	ADA134 791/3
1982	ADA149 595/1
1983	ADA259815/9
1984	ADA261408/9
1985	ADA259656/7
1986	ADA259816/7
1987	ADA259817/5
1988	ADA261407/1

Year	NTIS Accession #
1989	ADA259818/3
1990	ADA256161
1991	ADA256162
1992	PB2002100029
1993	PB2002100028
1994	PB2002100030
1995	PB2002100023
1996	PB2002100025
1997	PB2002100024
1998	PB2002100022
1999	PB2002100514
2000	PB2003100304
2001	PB2003101111
2002	PB2003107684
2003	PB2004106733
2004	PB2005106452